M.Sc Thesis

M.Sc Sustainable Development in Agriculture (Agris Mundus)
Track : Agricultural Development in Smallholder Farming Systems
Specialisation : MOQUAS

Participatory Development of Agro-Climate Advisories in Cambodia



Patrick Alexander SMYTZEK

Year: 2017

Partner institutions: **World Agroforestry Centre (ICRAF) and CARE**

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ABSTRACT

Title : Participatory Development of Agro-Climate Advisories in Cambodia

Agro-climate information services (ACIS) have the potential to facilitate adaptation among farmers, if they are actionable. An actionable ACIS provides useful and timely information, is accessible and understandable. This study assessed the potential for ACIS in the context of smallholder farming communities in Ratanakiri. PRAs, FGDs and interviews were combined to analyze the current situation, then different design options were developed and tested participatory. The cropping systems in Ratanakiri are highly dependent on seasonal rainfall patterns. The Perception of seasonal climate conditions vary among the population and are related to the experience of specific impacts. Currently, most farmers do not use climate information systematically in their decision processes. Barriers are the access, availability and the capacity to understand climate information. The ability to carry out desired actions is constrained by access to labor, land, technology and financial capital. Future climate change is likely to have adverse impacts on smallholder agricultural production in the area. The results suggest, that end-users have different capacities to access, understand and act on climate information. Socio-economic factors like gender, age and wealth influence these capacities. The design of agro-climate advisories requires a conscious balancing of trade-offs. Future research is needed to identify synergies that could arise from integrating ACIS with a wider system of extension services.

Key words

Agro-Climate Information Services; Participation; End-user groups; Ratanakiri; Forecast Design; Communication

Acknowledgements

Funding for this research was provided by the World Agroforestry Centre (ICRAF) under the M.Sc Fellowship program, the Direction générale des Études et Recherches (DGER) and the Région Occitanie, France. CARE provided logistical support and facilitated local transportation at the study site. The European Commission contributed indirectly to the funding of this study through an Erasmus Mundus scholarship, I obtained to pursue my M.Sc. degree.

I highly acknowledge the academic support from ICRAF, particularly Elisabeth Simelton *PhD*, who mentored and guided me throughout the research process and Rachmat Mulia *PhD*, who provided me with statistical advice. I also want to thank Tuan M. Duong and Tam T. Le.

Didier Pillot *PhD*, SupAgro Montpellier and Andreas de Neergard *PhD*, University of Copenhagen provided additional supervision.

Ngoun Nouth (CARE) and Khieng were crucial for this research as translators and I owe them my gratitude. Ngoun also played an important role as a thinking partner. CARE provided me with advice, recommendations and reflections along the process. I particularly thank Thira Heang, Duk Pun, Jan Noorlander and Erik Junge Madsen for their thoughtful comments and support.

I acknowledge the SA-OBS dataset and the data providers in the SACA&D project, the Global Climate Precipitation Centre of the Deutsche Wetterdienst, the UCSB CHIRPS dataset and data providers and the Climate Prediction Centre of the National Oceanic and Atmospheric Administration. Climate Data obtained from this source was used in this study.

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Acronyms

ACIS	Agro-climate information Services
ACIS Project	Using information to enhance the adaptive capacity of women and ethnic minorities in Southeast Asia Project (CCAFS)
CARE	Cooperative for Assistance and Relief Everywhere
CCAFS	CGIAR Research Program on Climate Change, Agriculture and Food Security
CEDAC	Cambodian Center for Study and Development in Agriculture
CGIAR	Consultative Group on International Agricultural Research
CIS	Climate Information Services
CPC	Climate Prediction Centre
DoP	Department of Planning
ENSO	El Niño-Southern Oscillation
FAO	Food and Agriculture Organization of the United Nations
FGD	Focus Group Discussion
GFCS	Global Framework for Climate Services
GPCC	Global Precipitation Centre
HH	Household
ICT	Information and Communication Technology
ICRAF	World Agroforestry Centre
KI	Key Informant Interviews
MEI	Multivariate ENSO Index
MoC	Ministry of Commerce
NCCC	National Climate Change Committee
PICSA	Participatory Integrated Climate Services for Agriculture
PSP	Participatory Scenario Process
PRA	Participatory Rural Appraisal
WMO	World Meteorological Organisation

Glossary

Agro-Climate Information Services:	The provision of climate information to agricultural end-users potentially combined with agro-advice.
Cham	Ethnic group in Cambodia, who identifies themselves as Khmer Islam
Chamka:	The upland rice intercropping system practiced as shifting cultivation by the indigenous population of Ratanakiri.
End-User:	Targeted beneficiary of a climate information services, who uses the information for decisions.
Climate Information Services:	The provision of climate information to facilitate decision making.
Kompong Siem:	Grey clayey soils formed from basalt with vertic properties.
Kreung:	Indigenous group of Ratanakiri
Labansiek:	Red clayey soils formed from basalt.
Participatory Numbers:	The use of participatory methods to generate quantitative data for descriptive or predictive statistical analysis.
Tampuen:	Indigenous group of Ratanakiri

1. Introduction

Climate change has been identified as one of the major global environmental challenges (Rockström et al., 2009) with strong negative impacts on agricultural production systems and food security (IPCC, 2014). Due to its dependency on climate and weather, agriculture is likely to be one of the sectors, which suffers most from future climate change. Managing risks and uncertainties is crucial within climate change adaptation efforts in agriculture (Howden et al., 2007). Uncertainty is an inherent characteristic of many management decisions regarding climate variability, that farmers face (Hansen, 2002). Climate information services (CIS) have been discussed as a way to help farmers adapt to climate change and cope with climate variability by informing their decisions(Patt, Suarez and Gwata, 2005; Roncoli et al., 2008; Hansen et al., 2011; Roudier et al., 2014) and eventually benefit them economically (Meza, Hansen and Osgood, 2008). With the creation of the Global Framework for Climate Services (GFCS) in 2011 the international community recognized the role that CIS play in the adaptation to climate change and variability (WMO, 2011). A climate service is hereby defined "[…] as the provision of climate information in such a way as to assist decision making" (Hewitt, Mason and Walland, 2012). To distinct CIS, which particularly target farmers and integrate components of agro-advice the term agro-climate information services (ACIS) will be used in this document.

There are many challenges to realise the potential of ACIS and make them actionable for the end-users in the context of smallholder farming communities in the global south, who are not familiar with the use of climate information and face barriers in accessing information and communication technologies (ICTs). According to Hansen (2002) seasonal weather forecasts can improve decision-making, if they address a real and perceived need, provide relevant information and are effectively communicated. This is also reflected in the GFCS, which emphasises the user engagement, needs and access (Hewitt, Mason and Walland, 2012). Communication of information to the end-users has been identified as a research priority for CIS among with the mapping of climate information needs and capacity building (Vaughan *et al.* 2016). Simelton *et al.* (forthcoming) propose the following 4 criteria for an actionable ACIS. The service needs to be (1) available, accessible and (2) understandable to the end user and provide (3) timely and (4) useful information.

To utilise seasonal forecasts is challenging for the end-users as they have to deal with unfamiliar information and integrate it into their decision making (Hansen *et al.*, 2011). Participation has the potential to both support the interpretation of forecasts (Patt, Suarez and Gwata, 2005; Roncoli *et al.*, 2008) and assure end-user engagement (Patt and Schröter, 2008). But attention needs to be given on how participation is constructed and how it might fail to capture power dynamics within groups (Roncoli *et al.*, 2011). If participation is employed without a reflection on power dynamics within communities and how they shape the outcomes of the participatory process existing inequalities can be reinforced.

The potential of ACIS is strongly limited by the exclusion of underserved end-user groups, which are often the most vulnerable in regard to climate variability (Archer 2003). Gender, wealth and ethnicity influence the access to climate information (Hansen *et al.*, 2011). Women farmers are due to their position in the periphery frequently excluded from communication channels of climate information (McOmber *et al.*, 2013). They do not share in many cases the same access to ICTs and face other barriers regarding education and language. Gender is interacting with other socio-economic factors, like age and wealth in shaping needs and the ability to act on climate information (Carr, Fleming and Kalala, 2016). Roncoli *et al.*, (2008) found that marginalized ethnic groups were excluded from the dissemination of forecasts in Burkina Faso.

In Cambodia, improved dissemination of climate information to end-users has been integrated as one element in the national strategic plan on climate change for the period 2014-2023 together with strengthening the forecasting system (NCCC, 2013). The north-eastern Province – Ratanakiri - is ethnically diverse and populated by different indigenous groups, who also have their own languages (Bourdier, 1995). The province has experienced major land use changes due to various drivers like population growth, migration, emerging cash crops, infrastructure development and land reforms (Fox, Vogler and Poffenberger, 2009). Predominantly, traditional shifting cultivation system practiced by indigenous communities have transited to market oriented mono-cropping systems and migrants have establish new cash crop oriented farming systems (Ruohomaki, 2003; Hor *et al.*, 2014). Migration and economic land concessions have led to a situation of increased land pressure and deforestation affecting the livelihoods of the indigenous populations (Fox *et al.*, 2008).

The changes in farming and livelihood systems are also reflected in a reconstruction of gender roles and relations (Park and Maffii, 2015). As the livelihoods and cultures of the indigenous communities have come under pressure from various sides (logging, hydro-power

projects, economic land concessions) (Ruohomaki, 2003), it are probably the women, who are have suffered from most of the negative consequences (Park and Maffii, 2015). Frewer (2017) argues, that this is by far not a simple causal relationship, but that gender relations are embedded in a wider net of socio-ecological relations, which are transformed by changes in the political economy. The uncertainties related to climate variability and climate change add another stressor for local farming systems and their managers. Climate related natural hazard like droughts and floods occur in the region with negative impacts on agricultural outputs (Nguyen, 2016).

1.1. Objective and Research Questions

The study aimed to analyse the current and potential roles of agro-climate information for adaptation to climate variability and future climate change in the smallholder farming systems of Koun Mom and Lumphat District, Ratanakiri, Cambodia. The study was expected to contribute to the development of better-informed and actionable ACIS. Particularly, the study aimed to explore gender related differences in understanding, needs and use of agro-climate information.

The study addressed the following research questions:

1. What are the major cropping systems practiced by smallholder farmers in Lumphat and Koun Moun district and how are they affected by climate variability and weather events?

2. What is the climate and its variability in Koun Mom and Lumphat district and how are they perceived among different socio-cultural groups?

3. How do different socio-cultural groups currently access, understand and use climate information? What are barriers, limitations and needs regarding climate information? What are gender-related differences?

4. What are limiting factors for farmers in climate sensitive decisions?

5. How can forecast products be designed to facilitate decision making?

1.2. Project Description

The study was embedded in an ongoing CGIAR research project. The "Using information to enhance the adaptive capacity of women and ethnic minorities in Southeast Asia (ACIS)" project is a regional project under the CGIAR's research program on Climate Change, Agriculture and Food Security (CCAFS) with study sites in Vietnam, Laos and Cambodia. The World Agroforestry Centre (ICRAF) Vietnam, CARE Denmark and the Cambodian Centre for Study and Development in Agriculture (CEDAC) implement the project in Cambodia. After a pilot in Vietnam since 2015, the project has been scaled out to Laos and Cambodia in 2017.

2. Methodology

A mix of quantitative and qualitative methods was employed to address the research questions. Such a combination of approaches is particularly suited to address the complexities inherent in environmental systems (Ashley and Boyd, 2006). Fig.1 illustrates the different phases of the research process with their purpose and the particular methods, which were used during each phase. Broadly the phases cluster into an analytical block (Phase 1 – 3) and into an action research block (Phase 4). Action research is "[…] a transformative orientation to knowledge creation in that it seeks to take knowledge production beyond the gate-keeping of professional knowledge makers […]" and requires that the researcher engages *with* the practitioners (Huang, 2010). It is an iterative process of construction, planning, action and evaluation (Coghlan and Brannick, 2010).

The analytical block formed the base on which different climate information products were developed and tested in the field together with the communities. The methodology is grounded in methods and ideas associated with participatory rural appraisals (PRAs) and the concept of participatory numbers. Participatory numbers refers to the use of participatory methods to generate statistical data (Chambers, 2007; Holland, 2013). Therefore a representative sample needs to be selected and data collection tools have to be adapted, that they are standardized and comparability is assured (Abeyasekera, no date; Barahona and Levy, 2002). It has been argued that participatory numbers can combine advantages from both

methodological bodies – the notion of empowerment associated with PRAs and the claim of representativeness usually more related to quantitative approaches (Barahona and Levy, 2007; Chambers, 2010). According to Gaillard et al. (2016) they have the potential to empower the most marginalized by giving their knowledge credibility. But there is a trade-off between the open-ended and community directed inquiry of classical PRAs and the required standardization in the data collection (Barahona and Levy, 2002; Holland, 2013).

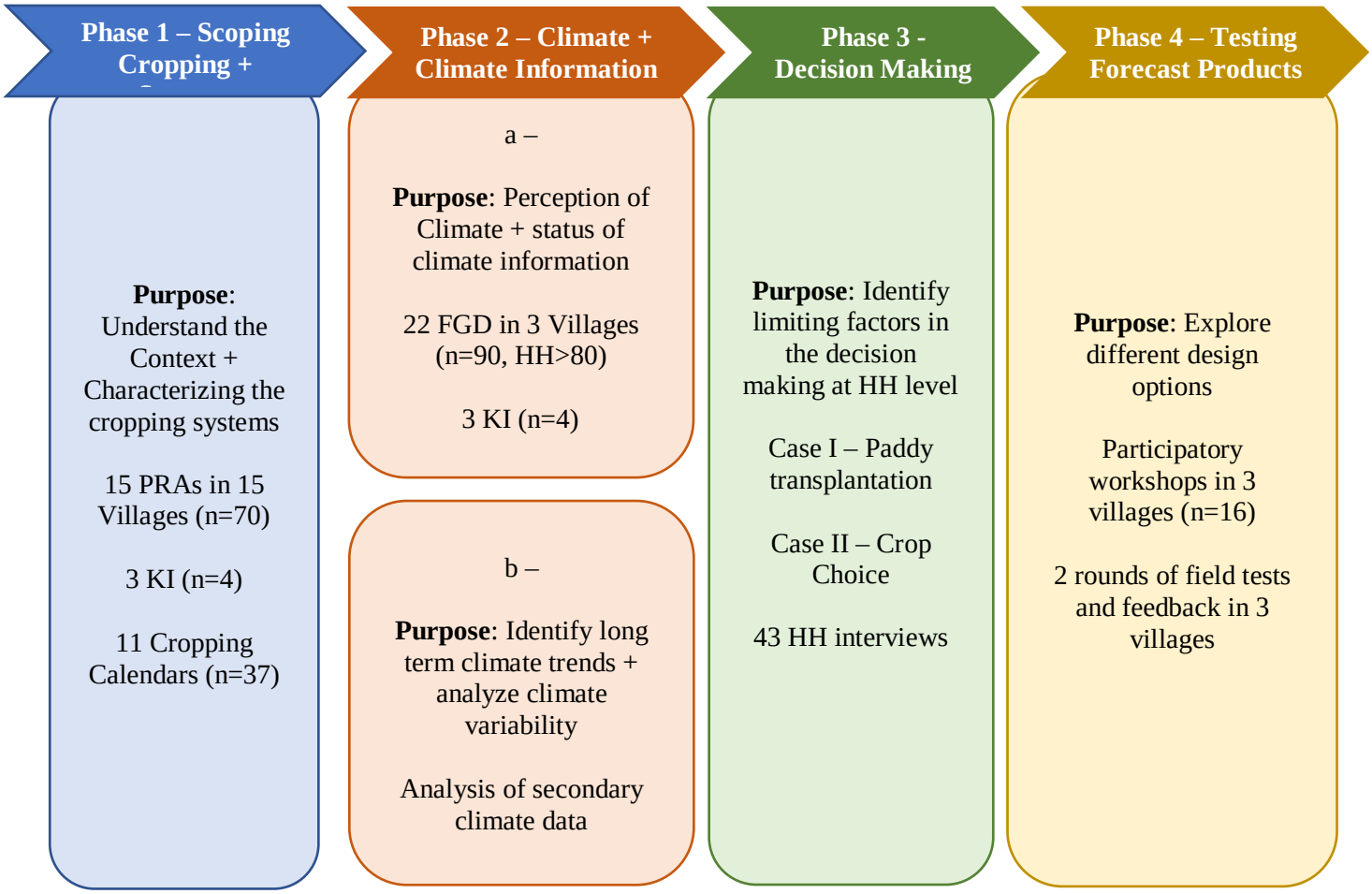


Fig.1: Outline of research process (Author)

The Data from the different Phases, different methods and different respondent groups were used to triangulate each other. Along the way, data was complemented with expert opinions by CARE and CEDAC staff, who have been living and working in the area for several years. Their local knowledge and experience were used to elaborate on the collected data. Translation from English to Khmer or the local languages (Kreung, Tampuen) and back was provided by two male translators, who identified themselves as Tampuen.

2.1. Study Site description

The study site is located in Ratanakiri, the northeastern province of Cambodia, 500 km from the capital Penh and consists of 15 villages, CARE and CEDAC have been working in under the ACIS Project. The Villages are in Koun Mom and Lumphat district close to the provincial capital Banlung. In Koun Mom 5 villages are in Ta Ang Commune and 4 in Teurn commune. In Lumphat district the 6 villages are in Seda Commune. Fig.2 shows the exact locations of all the villages.

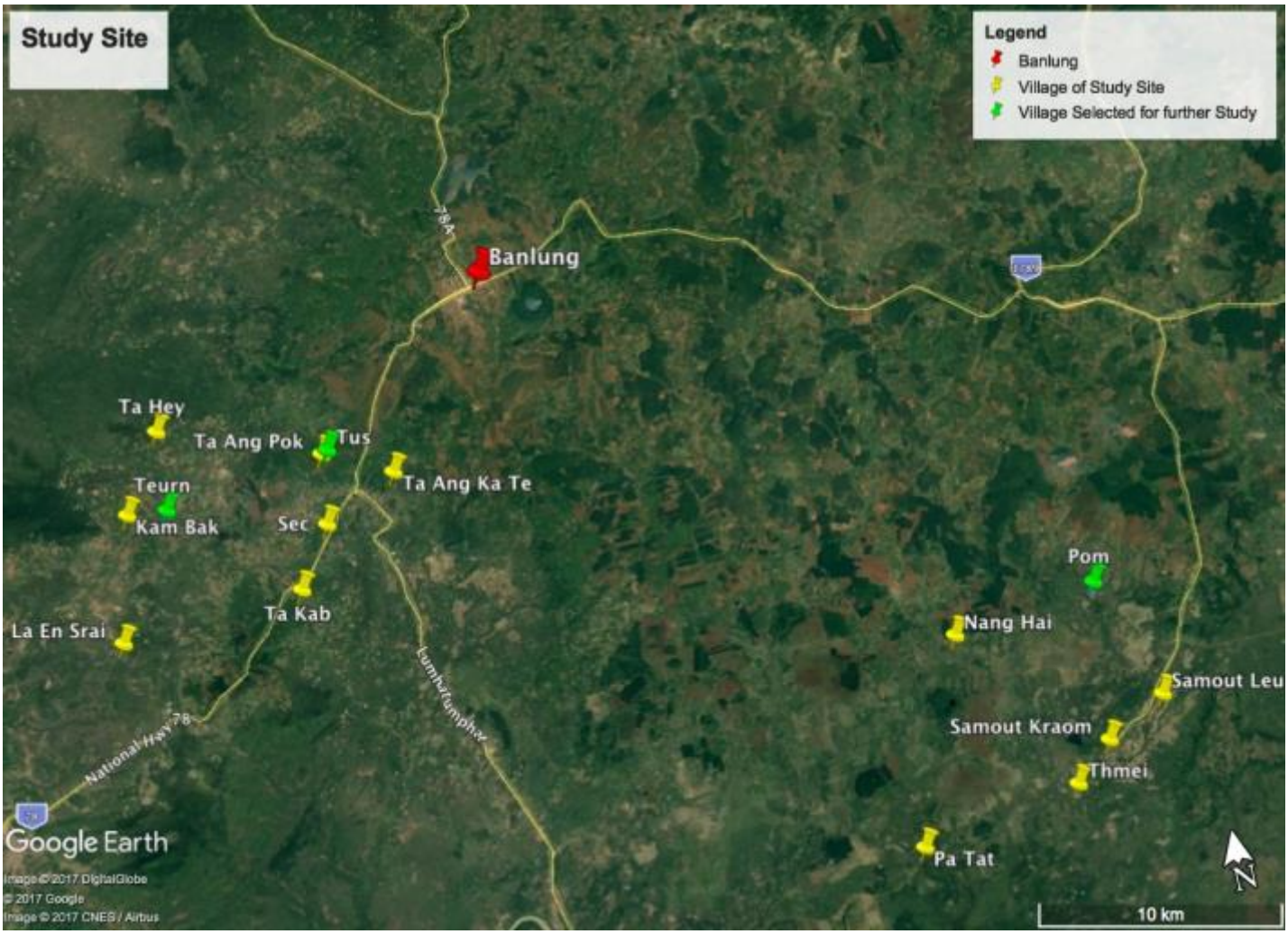


Fig.2: Satellite picture with exact location of villages of the study site. Villages which have been selected during a multistage sampling for further study are highlighted green (Google Earth, 2017).

The majority of the population in the study area belongs to two indigenous groups: Kreung and Tampuen. Tab.1 shows the latest population data from the Department of Planning (DoP) for the study area. The data did not prove accurate for all villages. It is important to note, that the DoP summarizes different ethnic groups under the term Khmer. The term is used collectively for all groups, which are not indigenous to the area of Ratanakiri including Khmer, Cham and Laos. In all villages except Teurn indigenous groups are predominant. In Seda commune the indigenous population is Tampuen. In Ta Ang and Teurn except La En Srai, the indigenous population is Kreung. La En Srai is the part of La En selected for the ACIS project and populated by Tampuen. Both groups have their own language. But members of the two groups described themselves in the emic-perspective as very similar in terms of their livelihoods, agricultural and cultural practices.

Tab. 1: Population data 2016 for Ta Ang, Teurn and Seda commune (DoP, 2017)

District	Commune	Village	Indigenous Group	Population	Share of Indigenous Population in %
Koun Mom	Ta Ang	Ta Ang Ka Te	Kreung	856	64.4
		Ta Ang Pok	Kreung	694	93.5
		Tus	Kreung	658	83.4
		Sec	Kreung	737	83.7
		Ta Kab	Kreung	706	82.0
	Teurn	Teurn	Kreung	1833	43.7
		La En	Tampuen	1094	83.0
		Ta Hey	Kreung	864	100.0
		Kam Bak	Kreung	686	80.3
Lumphat	Seda	Thmei	Tampuen	1166	100.0
		Pa Tat	Tampuen	536	100.0
		Samot Leu	Tampuen	1066	96.7
		Pom	Tampuen	568	100.0
		Nang Hai	Tampuen	1125	65.2
		Samot Kraom	Tampuen	1357	100.0

Ratanakiri is classified as equatorial winter dry (Aw) in the Köppen-Geiger system with the driest month having less than 60mm of rainfall and a minimum temperature of 18 °C throughout the year (Kottek et al. 2006). The climate is dominated by the southwest monsoon winds with heavy rains in summer and autumn (Nguyen, 2016). There is only one agricultural season from

Spring to Autumn. The major crops grown in the study area are cashew rubber, pepper, cassava, soybean, upland and paddy rice.

The study sites are located close to the provincial capital Banlung with the villages in Seda on lower and in Ta Ang and Teurn on higher elevation descending towards La En Srai. Elevation ranges from 120 to 240 m. The dominant soils are Labansiek and Kompong Siem as classified by White, Oberthür, and Sovuthy (1997). The Labansiek are red clayey soils, which can be used for upland rice. The Kompong Siem occurs in association with the Labansiek. Both are formed from basalt. The Kompong Siem has vertic properties and is grey to light grey. Rain fed paddy rice can be grown on this soil, which are mostly flooded during the rainy season. This soil type is dominant in Seda commune, due to the lower elevation, but some areas also occur in Teurn and Ta Ang in depressions and close to streams. In between the two soil types occurs a transition type which is brown in colour and seldom used for rice production (White, Oberthür and Sovuthy, 1997). Paddy rice is more important in Seda than in Ta Ang and Teurn due to the topography and soil conditions. In the uplands, upland rice is cultivated in a traditional rain-fed intercropping systems called Chamka[1].

2.2. Sampling

The study used a purposeful sampling strategy to assure the representativeness over a relatively small sample size in a context, where an appropriate sampling frame was missing and heterogeneity among the sampling units was assumed (Stern *et al.*, 2004). The study is based on a multistage sampling. After the scoping phase, 1 village in each of the 3 communes of the study site was selected for further study. The villages were selected to represent the diversity of the study site along a gradient of migration. The different location of the communes assured that environmental factors, like topography and soil types and the resulting differences in land use were covered.

In Seda, Pom a relative small Tampuen village was selected. The population of the village is exclusively Tampuen. The village is located remotely and does not have a good access to education facilities. The surrounding soil type is predominantly Kompong Siem (grey). Compared to the other two villages paddy is more important.

[1] Chamka in Khmer means farm and is used to refer to fields with a variety of crops excluding paddy rice fields, which are named Srai. But Chamka also refers explicitly to the traditional upland rice intercropping system of the indigenous population. In this document, the word Chamka is used to refer to later.

In Ta Ang, Tus was selected. Tus is a Kreung village with 4-5 Khmer families living in the village. It is located close to the national road and forms a cluster together with Ta Ang Pok. The dominant soil type of the surrounding land is the Labansiek (red).

In Teurn, Teurn village was selected. Teurn consists of two separate settlements, which administratively belong together and have in total more than 1000 habitants. One settlement is the original Kreung village. The other settlement is exclusively populated by people, who identify themselves as Cham or Khmer. Compared to the other two villages Teurn has seen much more migration from outsiders and has a relatively good access to education facilities. It is located further away from the national road, but forms the hub of the commune with several shops and restaurants along the main road. The surrounding soils are mainly brown in colour.

In the subsequent step, a stratified sampling strategy was used for Phase 2 of the research process and a targeted convenient sampling for phase 3. The specifics are explained in the sub-chapters for each phase.

2.3. Phase 1 – Scoping and Characterization of Cropping Systems

Phase 1 aimed to explore the context and the diversity of the study site and characterise the different cropping system regarding their climate sensitivity. It also provided the base for the multi-stage sampling on which the 3 villages were chosen as cases for further in-depth study.

In a first step a PRA session was carried out in all the 15 villages of the study site. The sessions lasted for about 2 ½ hours. The groups were gender mixed, except in Ta Ang Ka Te. Group seize varied between 3 and 5. In total 70 participants participated in the PRAs of whom 42 were men and 28 were women. In most cases the groups were chaired by the village chief or the deputy and included the village representatives in CARE and CEDAC's farmer learning network. Participants were selected via a convenient sampling using CARE's contacts as entry points, which resulted in a very strong bias towards members of indigenous groups, since these are the targeted beneficiaries of the project. Only 2 participants of the PRAs did not belong to one of the indigenous groups.

The first session in Ta Ang Pok consisted of a land use mapping and a timeline. For the other sessions, the timeline was then substituted with a crop ranking exercise and questions relating to the village development and history where integrated with the mapping. This allowed for a more efficient use of time and shifted the focus towards cropping system and climate

related issues. 6 Different crops were ranked according to their performance under 6 different weather and seasonal climate conditions[2]. The ranking question were formulated positively and a better rank indicated a better performance. After a rank was assigned the participants were asked to justify their choice. Participants recorded the maps and ranks themselves on a flipchart paper. In two villages[3] maps already existed. In these cases, the maps were used as a base and participants were invited to present them. In addition, participants were asked about the planting and harvesting period of different crops. The obtained data was complemented with 3 key informant interviews with commune officials. Questions focused on the development of Ratanakiri, current challenges and changes in the climate.

In a second step cashew, cassava, Chamka and paddy rice were selected for a more detailed characterisation, since they represent the most important crops for smallholders both indigenous as well as non-indigenous. The choice also captured a degree of diversity with a perennial, an annual cash crop, an intercropping system and an annual food crop. Soybean as another important cash crop was excluded due to time constraints. But Data on it was obtained during the PRAs and the Phases 2 and 3.

For each crop cropping calendars in relation to seasonal climate conditions based on Simelton *et al.* (2014) were constructed with groups of 3 to 6 participants. The discussions took 45 – 60 minutes. Except cassava, which was replicated only twice, each crop was replicated 3 times. In total 11 cropping calendars were constructed with 37 participants, 25 men and 12 women. Cropping calendars were recorded by the author on a flipchart. Participants were selected during meetings organised by CARE, CEDAC and the Agricultural Department at the provincial and communal level and included participants from the whole study area. Because of the sampling strategy there is a bias towards members of indigenous group, who speak Khmer, since the trainings were conducted in Khmer and targeted the indigenous population. To diversify the sample a group of 6 Cham men in Teurn was purposefully selected for a cashew cropping calendar. In addition, members of different ethnic groups were asked throughout the whole research process, what they perceive as differences, regarding the farming practices of different groups. This only revealed minor differences in the crop choices and the use of chemical and machinery inputs. It is very uncommon among non-indigenous groups to

[2] Cashew, cassava, soybean, paddy rice, Chamka rice, corn vs. droughts, hot spells, storms, early onset, late onset, long rainy season

[3] Ta Hey and Nang Hai

grow rice as a food crop and the use of inputs is slightly higher. Beside this most respondents stated that they do the same in terms of agricultural practices.

All sessions were recorded, notes were taken and the output flipcharts were photographed. The notes were organised in compilation sheets and coded. Both the construction of the compilation sheet and the coding were done inductively, which resulted in an emerging compilation sheet. The ranks were corrected according to a method suggest by Fielding, Riley and Oyejola (1998). In Case several crops got assigned the same rank by the respondents, the corrected rank consisted of the middle rank of the ranks which would have been assigned to the group of crops, if different ranks had been given[4]. Ranks were turned into inverted pseudo scores (Abeyasekera, Lawson-McDowall and Wilson, no date)[5] and averaged over all 15 observations. The Minimum and Maximum Values as well as the standard deviation were used to explore the range and variability of responses.

2.4. Phase 2 – Climate and Climate Information

Phase 2 is divided into two sub-phases: 2a based on the collection of qualitative and quantitative data in the field and phase 2b based on the analysis of secondary climate data. The overall objective of the phase was to reconstruct the climate, identify long-term trends and assess the status of climate information services in the study area.

2.4.1. Phase 2a – Field based collection of Data

The main component of this phase was a series of stratified focus group discussions (FGDs) in the 3 villages which were selected for further study. Criteria for the stratification were the ethnic group participants identified with (4 = Kreung, Tampuen, Khmer, Cham), the gender (men, women) and age (<30, >=30). In total this resulted in 22 strata over the 3 villages, since not all ethnic groups were present in all villages. In addition, the sample was complemented with 2

[4] E.g. Cassava and Cashew both got assigned the rank number 1 for drought. The corrected rank would be 1,5 based on the equation *(1 + 2)/2 = 1,5*.

[5] Rank 1 was turned into score 5, Rank 2 Score 4…

trials of mixed age groups, one in Teurn and one in Sec since they showed to be coherent with the overall results. 2 strata where left out in Teurn (young and old Khmer men). It became increasingly time intensive to mobilise both groups and it was expected that the results would not diverge from previous FGDs and add new data.

The FGDs consisted of 2 different parts and lasted for 60 – 100 minutes. First the seasonal climate was reconstructed for the seasons 2013/14 to 2017/18 in terms of onset and duration of the rainy season, evaluation of the overall climatic conditions, extreme events and impacts. In addition, participants were asked, whether they have perceived long term changes in the climate and to specify those. In a second part the current access, understanding and use of climate information was discussed and participants scored 7 different communication channels according to their preference on a scale of 0-5[6]. The FGDs were also used to collect individual data on the education level, age, the ownership of mobile phones and internet access.

In total 22 FGDs were carried out with 90 participants, 55 women and 35 men from over 80 HHs covering all the major ethnic groups. Participants were selected by a convenient sampling. This strategy was chosen, since farmers were very busy with planting during the period and spent a lot of time in their fields, which are located over a vast area and the lack of an appropriate sampling frame. For the indigenous groups the members of the farmer learning network were mobilised to select participants for the FGDs. In case of the none-indigenous groups, first a contact to a community member was established and then the community member was asked to help in organising the FGDs. Subsequently the participants of the FGDs were used to snow ball participants for other FGDs. A name list was kept for each FGD. These were used to identify ex-ante with key informants from each village, who is part of the same household. The FGDs were complemented with 3 key informant interviews with 4 participants from 3 different institutions involved in agricultural extension and advisory at the provincial level[7].

All FGDs and interviews were recorded and notes were taken. The notes were organised in compilation sheets and inductively coded for a qualitative analysis. For the seasonal climate reconstruction, a frequency analysis was carried out. The median and the extreme responses for

[6] Communication Channels: TV, radio, signpost/bulletin, NGOs, Agricultural Department, loudspeaker, mobile phones.

[7] Department for Water Resources and Meteorology, Agricultural Department, Department for Women Affairs

the onset and cessation of the rainy season for each year were identified. The frequency of the coded extreme events, temperature and rainfall descriptions was counted.

Quotes concerned with longer-term changes in the climate were organised using a process adapted from Simelton *et al.* (2013). First, they were grouped according to what factor they refer to: erratic rainfall, onset of rainy season, intra-seasonal rainfall, cessation of rainy season, temperature and extreme events. After that, they were organised in relation to how the change was described.

One and two-way ANOVAs were used to analyse the effects of socio-cultural factors[8] on the education level and a logistic regression was used to analyse the effects on mobile phone ownership among the respondents. SPSS was used for the analysis.

The scores from the FGDs were aggregated for different groups using either one factor or a combination of two factors to categorise the responses, e.g. men/women, younger women/older women. For the different groups the average of scores, the extreme values and the standard deviation was calculated. Because the homogeneity of answers no t-test or ANOVA was carried out.

2.4.2. Phase 2b – Analysis of Historical Climate Data

4 different climate datasets were obtained. Tab.2 shows the characteristics of the different datasets. From each dataset, a subset which covers a square in the geographic coordinate system on which all the villages of the study site are located was extracted. The upper left point of the square was defined as 13.75° N / 106.75° E and the lower right point of the square as 13.25° N / 107.25° E. The extracted subsets were averaged over the area. In case the data set used a different grid as reference the average was weighted to homogenise the different subsets. For the SA-OBS 1.0, several values were missing for the years after 2001, the missing values were constructed by spatial extrapolation. The average of the neighbouring grid cells was assigned to the missing grid cell. This was not possible for the years 2010 and 2011, since too many values were missing. The two years were excluded from the analysis. For the rainfall, the subsets were extracted for the period from January 1981 to December 2013 to analyse them over the same period. For temperature the subset was limited the period from January 1981 to

[8] Gender, ethnicity, age and location

Dec 2016, since the data showed two trend breaks before, which indicate a change in the recording equipment. The focus of the analysis was on rainfall, since it had been identified as the more important climatic factor during the PRAs.

Tab.2: Characteristics of the different climate datasets used in the study (Funk *et al.*, 2014; Schneider *et al.*, 2015; CPC, 2017; van den Besseelaar *et al.*, 2017)

NAME	VARIABLE	RESOLUTION	TIME PERIOD
UCSB CHIRPS V2P0	Monthly Precipitation	0.05°	Jan 1981 – present
GPCC FULL DATA MONTHLY VERSION 7	Monthly Precipitation	0.5°	Jan 1901 – Dec 2013
SA-OBS 1.0	Daily Precipitation	0.25°	Jan 1981 – Dec 2014
CPC GLOBAL LAND SURFACE TEMPERATURE ANALYSIS	Monthly mean temperature	0.5°	Jan 1948 – present

On base of the monthly or daily rainfall the total annual rainfall was calculated and plotted out for the different data sets. For each dataset, the minimum and maximum values were identified and the mean was calculated. To analyse the inter-annual variability the standard deviation and the difference in annual rainfall to the previous season was calculated.

The SA-OBS 1.0 was used for a frequency analysis of days with rainfall of a certain magnitude, since it is the only dataset, which provides daily values. It was divided into 3 time blocks: 1981 – 1991, 1992 – 2002 and 2003 – 2013 to see if there is decadal difference. The relative frequency for days with no rainfall, rainfall less than 10mm, rainfall between 10-20 mm, rainfall between 20-30mm and rainfall over 30mm was calculated. The relative frequency was used, because of the two missing years in the 2003 – 2013-time block.

For the temperature dataset, Kelvin were converted into °C and the annual mean temperature was calculated on base of the monthly mean temperature. The temperature data was plotted out over the period and a linear regression model was used for the analysis in Microsoft Excel.

To analyse the effects of the El Niño-Southern Oscillation (ENSO) on the seasonal climate conditions at the study site the Multivariate Enso Index (MEI) was obtained from Wolter and Timlin (2017). Following a ranking procedure adapted from Wolter and Timlin (2011), the mean of the MEI over each rainy (April – November) and dry season (December – March) between 1981 and 2017 was calculated. The rainy and dry seasons were then separately ranked according to their average MEI value. The upper 10 percentile was classified as strong El Niño, the 2nd 10 percentile as moderate El Niño and the 3rd 10 percentile as weak El Niño. For La Niña the lowest 10 percentile was classified as strong, the 2nd lowest percentile as moderate and so on. The seasons were then plotted out against their standardized seasonal mean temperature based on the CPC data set and the standardized seasonal rainfall based on the CHIRPS dataset. The Chirps dataset was chosen over the other two datasets, since it has higher spatial resolution, is more frequently updated than the GPCC dataset (Funk *et al.*, 2015), was found to have a high correlation with rain gauge data in the lower Mengkong basin (Guo *et al.*, 2017) and covers the period from 1981 to the present. The scatter plots allowed for a first visual interpretation. In addition, the seasonal mean MEI was correlated with the seasonal mean temperature and seasonal mean rainfall using a linear regression model in Microsoft Excel.

2.5. Phase 3 – Decision Making, socio-economic factors and access to communication technology

A structured interview guide was used to analyse the decision making at the household level and identify barriers and limitations for household. Two cases were identified. Paddy rice transplantation was used as a case, since the action was carried out by the household during the period of the study. This allowed for the collection of detailed information on the transplantation date and seedling age. As the other case the land use choice for the season 2017/18 were related to the experience of the last season was chosen. During the PRAs it was mentioned, that farmers planted more soybean in 2017 due to problems with cassava the previous season.

The sample for the first case focused almost exclusively on Pom, since farmers in Teurn and Tus do not cultivate paddy according to key informants and attempts to identify paddy farmers in the villages were not successful. The sample was complemented with 2 farmers in Ta Ang Ka Te, one farmer each in La En Srai and Samot Leu, after the sampling frame in Pom

had been exhausted. This also allowed for an exploration of location related factors like soil texture. The author visited a specific plot together with a household member. The status of the plot was observed and a soil sample of the top layer was taken to identify the soil texture with an ad-hoc feel method (Rowell, 1994). In a next step one or several household members were interviewed about household characteristics, farming activities, access to inputs, seasonal climate conditions and the specific management of the sampled plot.

In total 15 households[9] were sampled targeted according to whether they grow paddy rice. Respondents were approached either in their fields or at their houses. Interviews took between 30 - 40 minutes and were recorded on a recording sheet. The difference between the optimum and real age of the seedling were used to identify the households, which could not transplant, when they wanted. Households were classified as poor, neutral or wealthy according to the ownership of assets. A neutral household was defined as owning a motorbike and one communication asset (radio or mobile phone). A wealthy household owns an additional asset (tractor, TV…) and a poor household either has only one or none of the assets. Since the sample is very limited, the data was treated as anecdotic and not analysed statistically.

For Pom the questions regarding the land use choices were integrated with the questions for the paddy transplantation. In Ta Ang and Teurn an additional 30 interviews were carried out which only focused on the land use choices. Respondents were sampled conveniently according to their availability. During the sampling process, it was assured that the sampled households geographically distributed over the village and represent the ethnic diversity of the village. Participants were asked about their land use for the seasons 2016/17 and 2017/18. In addition, data on household characteristics, crop prices and last season's cassava harvest were collected. Interviews were recorded on a recording sheet. For each household the changes in the area used for different crops between the seasons were calculated and aggregated for the whole sample. Data on reasons for choosing different crops were analysed qualitatively in a compilation sheet. A logistic regression model in SPSS was used to identify relationships between socio-economic factors[10] and the ownership of different communication assets[11].

[9] 11 Households in Pom

[10] Size of accessed farmland and share of area under cashew cultivation. The wealth classification from the paddy case was not used, since it would have resulted in a tautology.

[11] Radios, mobile phones and TVs

2.6. Phase 4 – Developing Forecast Products

The action research phase was based on an iterative process. First 3 participatory workshops were facilitated, one each in Pom, Tus and Teurn. In total 16 participants (7 women, 9 men) took part in the workshops. The participants included the village chief or another village official and the champion farmers. The other participants were selected by the champion farmers according to their knowledge regarding agriculture. The workshops lasted 120 – 150 minutes. Participants were asked about their interest before the workshop and encouraged to ask questions and direct discussions.

During all the workshops a summary of the results from the FGDs was presented. This was used as a starting point to explore different communication strategies and develop concrete ideas for forecast formats. A simple card game was used to talk about uncertainties attached to forecasts. Cards showed a pictogram of rain or sun. One participant was asked to play the radio and give a forecast, whether it will rain tomorrow or not. The participant was then asked, to score how sure s/he is on a scale from 0-10. A deck of 10 cards was openly prepared with the number of cards, which show the forecasted event, equalling the given score. The deck was shuffled and another participant was asked, if it will be more likely to draw a card with rain or sun. A graph with historical rainfall data was used as another input and in Pom and Tus participants were confronted with a 3-day forecast from the Department of Meteorology. In Teurn only the °C temperature scale was discussed, due to time reasons.

On base of the workshops 3 different bulletin forecast formats were designed and distributed to the 3 communities. During the distribution groups of 3 - 5 people were gathered for feedback on them. All groups included at least one champion farmer. The champion farmers were encouraged to keep records, if the forecasts were correct or not and to collect more feedback from their communities, when they share the bulletin. The bulletin was displayed openly in all the 3 villages. The most promising idea was selected and redesigned according to the feedback. The improved version was then again distributed to the communities and objected to feedback. The different formats were also discussed with staff members of CARE, CEDAC, the Agricultural Department, the Department for Women Affairs and the Department for Water resources and Meteorology during two presentations and one capacity building event. In addition, a text message format was tested with the champion farmers in Tus and Teurn and a focal point in Teurn's Cham settlement.

The workshops were recorded and a memo was written, since the dynamics demanded that the author was fully attentive and not occupied with keeping notes. For the feedback sessions memos were written.

3. Results

This chapter presents the results of the study it follows the outline of the research process presented above.

3.1. The Cropping Systems and their Climate Sensitivity

The land use patterns within the study area are very similar. The most important cash crops for smallholders are Cashew, Cassava and Soybean. At the margin rubber and pepper are grown by a few households. But for most households those are not viable option because of the high instalment costs. Instalment costs also prevent poorer households from establishing cashew orchards. Peanut and mung bean are grown by a small number of households as annual cash crops. Farmland is either owned, rented or accessed through families. The farming systems usually consists of different plots distributed over an extended area. During the harvesting and planting periods farmers partly live in small houses and huts in the plots and travel between them. The men usually control the motorbikes of a household and are more mobile. There is a stereotype prevalent among all ethnic groups, that women have difficulties to drive during the rainy season.

Among the indigenous households, it is common to complement the cash crops with paddy rice or an upland rice intercropping system called Chamka for auto-consumption. The share of Paddy depends on the location of the specific village, the surrounding soil and topographic conditions. Paddy is more important in the lower lying areas of Seda, as in Ta Ang and Teurn on higher elevation. But also in Ta Ang and Teurn are villages, where a notable share of farmers cultivates paddy in depressions and close to streams (Sec, Ta Ang Ka Te, La En Srai). Compared to Chamka, Paddy has the advantage that it is not under pressure from cash crop production as the water logged soils cannot be used for cassava, soybean or cashew. Growing rice is less common among the Cham and Khmer communities. Farming activities are complemented in many cases by extensive husbandry and occasional farm work. This work is

carried out within the villages mainly during planting and harvesting, but also for weeding activities. It is very uncommon among the indigenous people in the study area to work in commercial plantations.

The climate sensitivity of the different cropping systems is dependent on the timing of the cropping calendars and the phenological state of the plants. Most of the cropping systems are rain fed and only small areas can be irrigated manually, with a pump or by diverting water from streams. Fig.3 shows the calendars for the main crops and a synthesis of what is considered a *normal* season, which ranges from April to November. Overall the cropping systems are fairly homogenous among the smallholders in the study area. After a short description of the agricultural change in the area, the different cropping systems are described in more detail.

Month	J	F	M	A	M	J	J	A	S	O	N	D
Temperature												
Rain												
Season			Early	Onset	Late					End	Long	
Cashew		Harv.				Plant.					Flow.	
Cassava				Plant.								Harv.
Soybean							Plant			Harv.		
Chamka Veg				Plant.				Harv.				
Rice					Plant.				Harv.			
Paddy Rice						Prep.	Plant.				Harv.	

Fig.3: Cropping Calendars. Different indicate shades indicates higher/lower temperatures, higher rainfall and relative frequency of response for cropping activities (Author's fieldwork).

3.1.1. Agricultural Change in Koun Mom and Lumphat

The traditional livelihood system of the indigenous populations in Koun Mom and Lumphat was solely subsistence oriented and centred around the Chamka, which was practiced as a shifting cultivation system. In addition, forest resources were used for livelihoods. Poaching, collecting bamboo shoots and mushrooms were important sources of food. Both the forest and

the cycle of the Chamka are reflected in the spiritual and cultural practices of the Tampuen and Kreung.

During the PRAs and KIs the respondents described an agricultural transition from subsistence to cash crop oriented farming systems accompanied by deforestation. This transition is embedded in the broader development of the province and fuelled by migration, infrastructure development and establishment of economic land concessions for rubber, pepper and cashew plantations. The first migrants from other provinces started to come as workers in the plantations, but then established their own farms. This transition was associated with an increase in living quality. Other waves of migration followed, mostly from their home communities and particularly for agricultural opportunities.

The Migrants introduced new cash crops like soybean, cassava and cashew to the area, which got adopted by the indigenous population. Better market access through improved road conditions and the possibility to earn money sparked a shift towards cash crop oriented farming systems among the indigenous groups. Cashew is of high importance for smallholder farmers in the area today. It is the preferred crop both in Lumphat and Koun Mom and associated with wealth, a steady income and a low labour input. It started to appear in the 1990s and boomed in the early 2000s. Since then the area under cashew cultivation has continuously expanded and the recent high price has led to a further increase of cashew

Together with migration and economic land concessions, the shift towards cash crops resulted in increased land pressure. Eventually agricultural land expanded on forested land as the plots of the indigenous communities were pushed further into the forest and plots were not left fallow anymore but utilised for cash crops instead.

Land availability is a major concern in all the 15 villages. During all PRAs it was said, that it has become increasingly difficult to find new land for Chamka plots. As a result, farmers have shortened the fallow periods, decreased the share of food crops in their farming system, moved to more marginal land and eventually become more dependent on food purchases. In Kam Bat, Ta Ang, it was explicitly stated that the land shortage has led to a pattern of seasonal migration, where villagers seek agricultural opportunities in other villages during the rainy season and come back for the dry season.

3.1.1.1. Cashew

Cashew orchards are managed under various degrees of intensification. The most intensive systems use hybrid cultivars, a narrow spacing (5-6 m), fertilizer and pesticide application. The rotation period is relatively short with 10 years. The least intensive systems are characterized by traditional cultivars, a wide spacing (up to 16 m), no fertilizer and pesticide application and a long rotation period of up to 30 years. The individual capacities of a household influence the degree of intensification. Establishing a new orchard with hybrid cultivars costs than using a traditional cultivar.

Young trees are planted between May and July. Red, brown and black land is used for cashew. Red soils were indicated as a preference. Cashew is sensitive to water logging and needs well drained soils. Two cultivars are dominant: a traditional cultivar and the M23 hybrid. Before the planting the trees are usually crafted. The seedlings for the base are either bought from a nursery or raised by the farmers themselves. The planting is considered successful, if the seedling survived 1-2 months and new leaves have formed. For the first 3-5 years, the young trees can be intercropped with soybean, peanut, mung bean or cassava. This optimizes the space and reduces the need for weeding. Soybean is the most common intercrop. After 3-5 years, the canopy has become too dense and the intercrop interferes with the flowering and fruit forming. If fertilizer is applied, it is timed to the flower in October and November. Weeding and herbicide application are carried out according to Observations.

First fruits are ready for harvest in December and January, but the main harvest falls between February and Mai. The traditional cultivar can be harvested for the first time after 4-7 years, the hybrid already after 2-3 years. Fertilizer application shortens the period to the first harvest. Revenues for the hybrid (2000-2500$/ha) are 2 times higher than for the traditional cultivar (800-1250 $/ha). This is attributed both to higher yields and higher prices. In some cases, Cashew orchards are rented out for the annual management or the harvest both within the province, but also to people from other provinces, who migrate to the villages for the harvest period. When the trees start to decrease in production, they are cut down and in most cases the orchard is replanted or the land is used for a short cycle of annual crops before it is replanted.

On average Cashew was ranked as the best performing crop under conditions of droughts and hot spells (see Fig.4). The variability in the answers was relative low. Only one group ranked it in the lower half and half of the groups gave it the best rank for both items.

During the ranking participants referred to an adult tree. The young trees are more sensitive to climate and weather related stresses, because of their small size and root system. In case younger trees die, they are replanted. The flowering period is a weather sensitive period. Rainfalls, droughts and hot spells can affect the flower negatively and result in a lower harvest. Cashew was ranked on average relative low against storm. This was justified by its seize, which makes it sensitive to be damaged by strong winds. If the damage is not to severe trees can be straighten up again and branches are supported with clutches. Moreover, respondents described the cashew flower turning black, resampling a burnt appearance during autumn 2016. Subsequently less fruits were formed. The reason and whether there is a relation to weather conditions is unclear. The affected trees showed signs of blight infections. However, it was impossible to identify the cause in a post-assessment with no observations of the flowers.

3.1.1.2. Cassava

The planting of cassava normally falls between March and May depending on the onset of the season. Red, brown, black and grey land are used for Cassava. The soil is prepared either with a hand tractor or by hand. Planting material is accessed through other villagers or propagated by the households themselves. Cultivars in use are Malay, Joun, Drakun and Sway. Malay and Joun are more productive. Horizontal planting is preferred because of the reduced labour and machinery input. Sometimes pesticides are applied during the planting. To a very small extend cassava is intercropped with mung bean or corn. Fertilization is not common, but herbicides are used more widely. Weeding is done according to observations by hand or with an automatic scythe. Cassava fields in Ta Ang and Teurn were infected with the Cassava Mosaic Virus in the season 2017. Seda is less affected. Farmers' knowledge to respond to the outbreak is very low and infected plants are left in the fields.

Cassava is harvested from December up to March/April. It is very productive in terms of yield (7.75 – 15 t/ha). But the price is volatile and has been particularly low for last season's harvest with 0.03 – 0.13 $/kg depending on the time of the harvest and the quality. The price usually decreases towards the end of the harvesting period. Accordingly, the revenues can vary widely between 200 – 2000 $/ha. After the harvest the roots are cut and dried. Like for cashew, fields are sometimes rented out for the harvest, which also shifts the risk for harvest failure and postharvest damage to the renting party.

As a crop, which is planted early in the season, Cassava was ranked on average as the worst performing crop for a late onset (Fig.4). In cases of late rain farmers respond by delaying the planting date up to July and change in some cases their crop to soybean, which is planted later. Cassava is storm resistant and was ranked exclusively in the upper half on this item. Arguments for the high ranks were, that it continues to grow even it falls during storm events and that the roots are protected in the ground. A frequently mentioned problem was interference with rain during the drying of the root, which makes the root mouldy. Respondents referred to it both in relation to an early onset and a long rainy season. Farmers respond to this by investing into protective structures like plastic covers or by not harvesting some area of the Cassava and using the labour for other activities. Also, intense rainfall shortly after the planting was said to be a problem, since it causes the cuttings to rot in the ground. Regarding drought Cassava was ranked on average as relative resistant.

3.1.1.3. Paddy

The land for paddy is prepared in June by wracking the soil one or two times with a hand tractor. Grey and black land are used for paddy cultivation. The colour can go into a reddish pale brown. The texture varies from clay to sandy clay. At the same time as the land is prepared the nursery is prepared two. The seeds are soaked 2-3 nights in water and then broadcasted in the nursery next to the fields. After 15 – 45 days the rice is transplanted. No hybrid cultivars are used, but a vast number of traditional cultivars exist. Most villages have their own cultivars. Seeds are propagated within the villages and can be exchanged between villages.

Fertilizer and pesticides are usually not applied. Weeding is done according to observations, but not every household weeds in the paddy fields. There is no systematic manure management. Buffalos and cows can enter the fields during the dry season. Most paddy areas are rain fed and only a small extend can be irrigated by diverging water from streams or pumping water into the fields.

Occurring problems with paddy rice are pests like birds, snails and crabs. Snails and crabs thrive particularly under wet conditions. It was also mentioned that rice is reddish or yellowish in colour. This has been described as a disease, but probably indicates a phosphorous or nitrogen deficiency. The harvest is almost exclusively used for food consumption and only

if there is a surplus, rice is sold to other households in the village. Farmers indicated that the yield varies from 2 – 4 t/ha.

Paddy was ranked on average relatively low towards all weather conditions (Fig.4). As rain fed systems it is perceived as sensitive towards drought events. A certain amount of rainfall is necessary for the transplantation and participants of the cropping calendars stated, that they not utilise the plots, if there has not been enough rain. Heavy rain events during the flowering period can result in quantitative losses by damaging the flowers. Some traditional cultivars get quite tall (up to 1.5 m) and are easily affected by strong winds. In case the damages are not to severe, farmers straighten the plants manually.

3.1.1.4. Chamka

The Chamka is a mixed upland rice system in which vegetables (cucumber, pumpkins) and stables (taro, coco yam, corn) are intercropped with different rice varieties. As a result, it provides a diverse and nutritious diet over the season. The cultivation of different rice varieties with different maturing times allows for a stretched harvest over a longer period. This reduces storage time and provides rice for timely consumption. The Chamka harvest ends the period of food insecurity that some household face. Depending on the village this period ranges from April to September and affects up to 50% of the households. Members of the indigenous groups frequently expressed the significance of Chamka for their livelihoods.

The land for a new Chamka plot is selected and prepared during the dry season from January to April. The land is cleared. Grass, shrubs and trees are cut down and burned. Soft red land without rocks or stones, which has been forest or left fallow for a long period (10 years) is ideal. But brown land is also used too today as a response to land shortage. The vegetables, spices, corn, yam and coco yam are planted before the Rice in April and Mai. The spots for each plant are purposefully selected mostly around tree trunks, which provide shade and where the ash is concentrated. Rice is then planted between Mai and July. The plots are divided into different sections attributed to different rice varieties. There is a huge diversity of rice cultivars and many villages have their own varieties. Cultivars can be divided in short and long

maturing[12]. The short maturing cultivars can be harvested between September and October, the long maturing after November. Farmers appreciate the diversity in their nutrition.

Fertilizer is usually not applied in the Chamka. The weed management is intensive and done either manual or with herbicides according to observations. Also for the Chamka rice farmers referred to a reddish or yellowish colour indicating a phosphorous or nitrogen deficiency. Pest problems are root borers and birds. The vegetables are harvested in August and September before the rice. The harvest period for the rice stretches from September to January. The harvest is almost exclusively used for auto consumption. Only if there is a surplus it is sold to other households in the village. Famers' indicated yield varies from 1 – 4 t/ha, whereby 4 t was an exceptional good harvest. Traditionally the Chamka was practiced with a cropping cycle of 3-4 years and a fallow of 10 years. But this practice is constrained by the shortage of suitable land. In most cases a plot is not left fallow anymore but goes through a transition of cassava and/or soybean before it eventually becomes a cashew orchard. On more marginal land, which is used nowadays, the cropping cycle comes down to 1-2 years.

Like paddy, Chamka rice got overall relatively low ranks towards all weather conditions (Fig.4). It is very dependent on rainfall and drought sensitive. Heavy rain events during the flowering can reduce the yields. Too much rain during the planting is another problem, since it can cause the seeds to rot. Households can respond by replanting.

3.1.2. The climate sensitivity of other cropping systems

Soybean was frequently mentioned to be sensitive towards hot temperatures and droughts because of the small rooting system. On average, it was ranked relatively low on all items except late rain (Fig.4), since it is planted in June and July. Low ranks for an early onset were assigned, because the planting material gets destroyed if there is too much rain after the planting. Households respond to this by replanting. The low ranks for a long rainy season were explained by the fact, that the seeds spoil or germinate, if there is too much rainfall during the period of maturing.

Corn got in most cases assigned the same rank as the Chamka, since it is usually intercropped with it. In one village participants said, that they grow corn next to a stream, which

[12] Short maturing cultivars include: Krein, Kavet, Chrin, Pkytop, Kajay
Long maturing cultivars include: Solea, Kansian, Sroch, Pey, Paky, Nag Lai

allows them to irrigate it manually in case of drought. Compared to the other weather conditions it is ranked slightly better on a long and early rainy season. A high rank was usually justified by the argument, that a long enough season allows to crop two cycles of corn. It is one of the first crops farmers plant in the season. Because of it its height it is affected by storm events.

During the PRAs mung bean was mentioned as a crop, which could benefit from an early onset, since it can then be grown twice, if the season is long enough. Banana was mentioned as a storm-resistant crop and pineapple as a heat tolerant crop. Both crops are not grown on a commercial scale by households in the study area.

3.1.3. Adaptation and Coping

Smallholders base their farming practice on rain fed cropping systems and are very dependent on the seasonal rainfall conditions, which affect the crops differently (Fig.4). The management options that farmers have in the current situation to adapt and cope with weather impacts are limited. They include crop choices, the timing of planting and harvest, off farm labour to buffer for losses in farm income, manual irrigation and manual treatment of storm damages. Participants of the PRAs and the FGDs perceived their own adaptive capacity as very low as they frequently stated that there is nothing they can do to protect and support their crops in case of adverse weather conditions. As one young Tampuen man in Pom put it: “We are not gods, we cannot change the weather”.

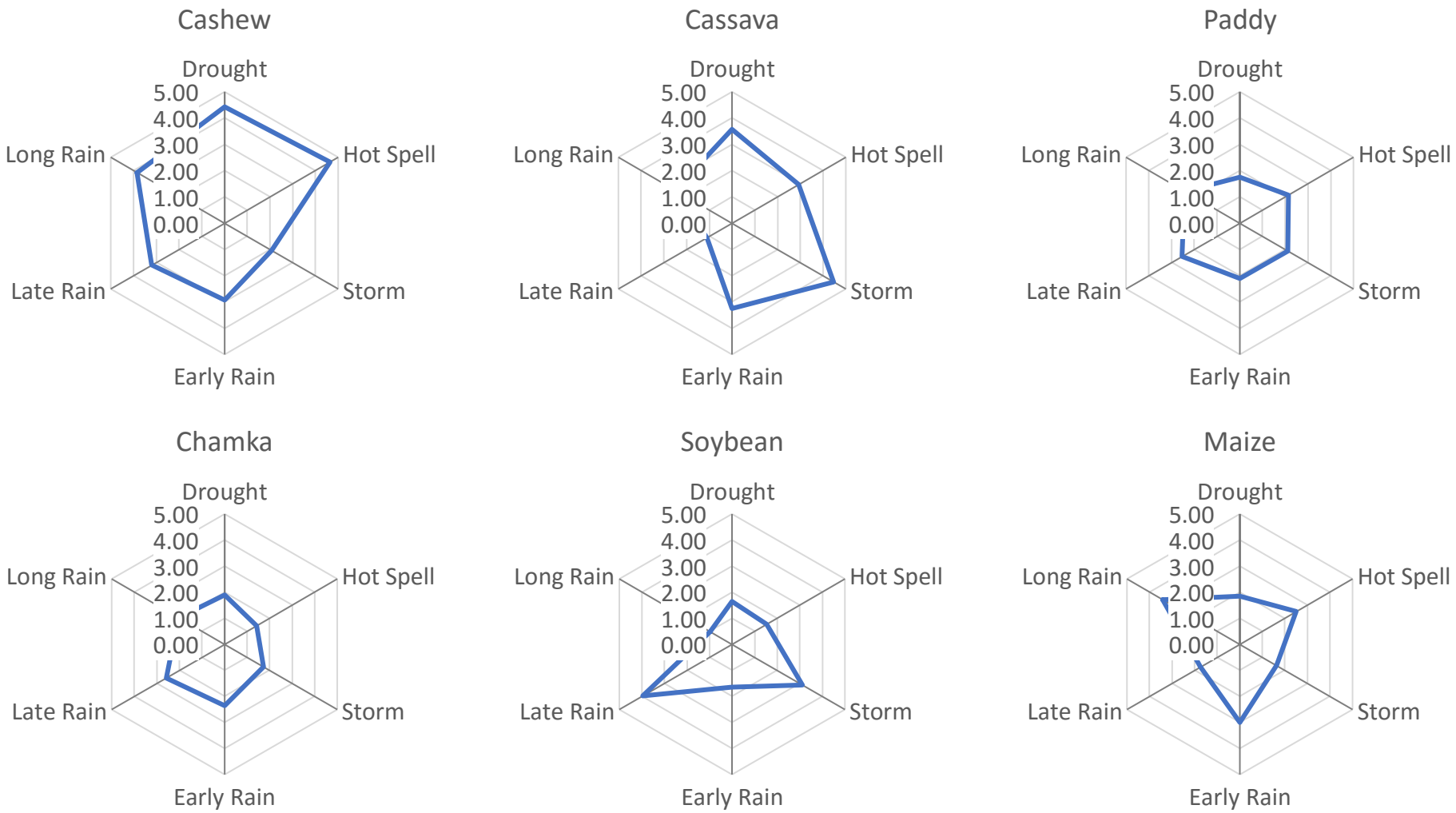


Fig.4: Perception of Crop performance in relation to different weather events. A higher score on the radar indicates a better performance (Author's fieldwork)

3.2 Climate and climate Variability

Seasonal climate variability is an important factor for the rain fed cropping systems in Koun Mom and Lumphat. This chapter will look at the perception and observations of climate variability and longer term changes. Then the effects of ENSO on the seasonal climate conditions are presented.

3.1.4. Climate Reconstruction and Impacts

Tab.3 shows that while dating the onset during the FGDs varies widely for each season, there are certain trends. Most focus groups agreed that the onset was between March and April for the seasons 2013/14, 2014/15 and 2015/16, while there was more discrepancy for the past two seasons. The onset for the season 2015/16 was perceived relatively late with May as the median response and March and July/August as the extreme responses. The onset of the season 2017/18 on the contrary was perceived as relatively early with March as the median response and February and May as the extreme responses.

For the cessation, the most common time was November/December, the earliest stated as October, while the latest month became later each season. For the cessation 2016/17 the answers varied particularly with some respondents stating, that there was continuous rainfall and the season blended into the next season. For both onset and cessation no difference between gender, age or ethnic groups can be established. Specific experiences played a crucial role in the recalling of events, e.g. “I remembered we were planting Cassava, when the rain started” – women farmer in Teurn. Their was no systematic difference between the perception of the onset and cessation among different socio-cultural groups.

For comparing the seasonal rainfall between different years, the FGD-participants took a number of indicators of exposure into account (e.g. the length of the season, the timing of the onset, the overall amount, frequency, intensity, spatial and temporal distribution of rainfall events, extreme events and whether the rain was related to storms), nevertheless the conditions were more reflective of impacts, especially crop failures, on human health and housing. A common description of rainfall is summarised in the following quote by a female farmer from Tus village in Ta Ang: “There was rain, rain, rain for long time and then hot, hot, hot”. She refers both to the duration, intensity, frequency of rain and the absence of rain associated with higher temperatures. Younger respondent groups tend to use more frequently middle values for

the evaluation compared to older respondent groups. The non-indigenous groups evaluate all the seasons except 2016/17 on average more positive than members of an indigenous groups.

Tab.3: Seasonal climate reconstruction from 2013/14 to 2017/18 (Author's fieldwork). Font styles for rainfall, temperature and extreme Events: **BOLD WITH CAPITAL LETTERS** denote answers mentioned in at least 10 FDGs; Regular during 6 to 9 FGDs and *italic* during 3 to 5 FGDs. An empty cell denotes, that less than 3 FGDs referred to the parameter. The Cessation 2017/18 had not yet occurred at the time of the study.

		2013/2014	2014/2015	2015/2016	2016/2017	2017/2018
Onset	Earliest Response	Mar	Mar	Mar	Mar	Feb
	Median	**Apr**	**Apr**	**Apr**	**May**	**Mar**
	Latest Response	May/Jun	Jun	Jun	Jul/Aug	Apr/May
Cessation	Earliest Response	Oct	Oct	Oct	Oct	
	Median	**Dec**	**Nov/Dec**	**Nov/Dec**	**Dec**	
	Latest Response	Dec/Jan	Jan	Feb	May	
Rainfall	Amount	*high*		*high*	*low*	**HIGH**
	Temporal Distribution			Uneven	*uneven*	*uneven*
Temperature			Hot / cold	*Hot / cold*	**HOT**	Hot
Extreme Events				Drought	**DROUGHT**	
		storm	Storm	**STORM**	Storm	**STORM**
		flood	*flood*			*flood*

The reconstructions for the seasons 2013/14 and 2014/15 are not very detailed. A few respondent groups referred to floods, which affected crops and killed animals particularly chickens for both seasons. It is not clear, if these groups referred to the same event, but remembered the timing differently. During the season 2015/16, particularly strong storms occurred. Besides damaging houses, they also destroyed cashew plantations. One respondents group even described a tornado with gestures. Another theme that occurred is an uneven, extreme distribution of rainfall during the season with prolonged intense periods of rain followed by dryer and hotter periods.

The season of 2016/17 was remembered as relatively dry in conjunction with a late onset and high temperatures. Droughts are the most frequent extreme event mentioned for this season and in most cases, they are dated to the beginning of the season up to July, which also can be interpreted as a late or false onset. Participants said, that they responded to this by delaying their cassava planting, which in many cases was not perceived as a problem. Other crops affected by the droughts were rice and soybean. The season was followed by unusual rainfall during the dry season, which interfered with the drying of the Cassava. This resulted in quantitative and qualitative losses.

The rainfall of 2017 so far was evaluated most frequently as not good. These evaluations are based on the high amount ("too much rain"), the intensity and the uneven distribution of rainfall – intense and long periods of rain followed by long, hot periods without rain. The periods with intense rainfall caused planting material (seeds and cassava cuttings) to rot after the planting. Cassava, soybean and to a lesser extend rice are affected. The extreme rainfall also interfered with weeding activities. The early onset has been an opportunity for some but a disadvantage for others, since they could not prepare their fields on time and the rain interfered with their preparations.

3.1.5. Perceived Changes in the Climate

Participants were aware that the seasonal weather varies from year to year and how this impacts their crops' yield and quality. During all FGDs participants acknowledged that there is seasonal variability in rainfall. But a majority stated, that beside the seasonal variations, they did not perceive any longer-term changes. It is important to note, that a term for the concept of climate does not exist in the local languages. There is only a word for weather. This indicates that climate as a category to structure perception is absent in the language systems.

Tab.4 shows quotes respondents used to describe changes in the weather and climate organised according to what they refer to and which dimension they describe. In the case, that a longer-term change was perceived the most frequently mentioned one was, that there is now more variation in the onset of the rainy season. Particularly in Seda, the participants said, that the rain is now spatial fragmented – some areas receives sufficient rain and other areas not. Other recurring themes are changing frequency of the rain (rain and then a period with no rain)

and intensity (quicker, stronger and faster rains), which result in a more extreme and uneven distribution of rainfall usually described as “rain, rain, rain and then hot, hot, hot”. When an explanation for the change was given, it was always related to deforestation. In a few cases participants said, that “now it is hotter” and that “rain events now come with storms”. Regarding temperatures only higher temperatures and longer hot periods were mentioned, no FGD referred to a decrease in temperatures or more extreme variations. For some participants, just the last years were exceptional and strange. Others stated that the climate started to change from 1979 onwards.

Tab.4: Examples of quotes of perceived changes in the climate from Ta Ang (TA), Teurn (TE) and Seda (SE) commune. Similar quotes have been merged. (Author's Fieldwork)

Erratic Rainfall	Some areas have good rain, other areas have not enough rain. The rain is not evenly distributed anymore. (SE, TA)			
	Timing			**Inter-annual Variability**
Onset of Rainy Season	There is more variability in the start of the rain. This year rain started even without the traditional prayer. (TE) The time of the onset has been more extreme for 10 years. If it is early, it is earlier. (TE) The rain is not on time anymore (TA) Now we grow rice in June/July, because the rain is too late. This has changed since 2000 (TA) Since the forest is gone, the start of the rain varies (SE)			Normally the rain started in April/Mai. Now it varies some year it is earlier, some year it is later. (TE, TA, SE) Normally the rain is on time. Only recently (last 1-2 years), it has been different (TE, TA)
	Amount	**Frequency**	**Intensity**	**Inter-annual Variability**
Intra-Seasonal Rainfall	Long time ago, we had less rain. (TA)	Now the rain is different. Rain and then 6-7 days without rain. (TA) Since 2013 we have one week rain and then up to one month without rain (TA) The rain is longer and hot and dry periods too (SE) It is just rain, rain and then hot, hot. This is different (TA)	The rain is very quick and strong and other times normal. (TE) Some days there is a lot of rain and it is fast. This is new. (TA) The extremes are more. When it rains a lot, it rains a lot. (TE)	Some years have a lot of rain, others not enough. (TE, TA, SE) Some years it is dry for a long time (SE) In 2004-2005 there were long rains followed long periods of no rain. (TE)
		If it rains, it rains a lot. If there is no rain, then there is no rain for a long time. This is different from before (TA)		
Extreme Events	Cutting of the trees caused droughts, flood and more rain. (SE) More storms (TE, TA) The rain is coming with storms now (SE, TE)			
	Amount	**Duration**		**Inter-annual Variability**
Temperature	It is hotter than before (TE, TA) After rain, there is strong sun. This is new. (TE)	Hot periods are longer, because trees are gone (TA, SE)		The last two years were very hot (TE) Some year it is hot for a long period (SE)
Confounded Perception	The rain was not acid. But now the first rain is acid rain. (TA)			

3.1.6. Historical Climate Data

Fig.5 compares the annual total rainfall from different datasets for the study area for the period from 1981 – 2013 and Tab.5 shows descriptive parameters for the same period. For the UCSB CHIRPS v2p0 annual rainfall varies between 1871 and 3062 mm, for the SA-OBS 1.0 it ranges between 830 and 2370mm and for the GPCC Full Monthly Data 7.0 between 925 and 2530 mm. In general, the SA-OBS 1.0 tends to provide lower values than the other two datasets. The GPCC and CHIRPS show a similar progression over the period, the SA-OBS picks up on the extreme values. The average annual rainfall over the period is 2272 mm for the UCSB CHIRPS, 1968 mm for the GPCC and 1348 mm for the SA-OBS dataset. Although there is discrepancy between the three datasets, they all show a high inter-annual variability. The standard deviation is similar and the maximum inter-annual variability is substantial in comparison to the mean (Tab.5).

Tab.5: Descriptive parameters of 3 different rainfall datasets for the period 1981-2013 averaged over the study area (Funk *et al.*, 2014; Schneider *et al.*, 2015; van den Besseelaar *et al.*, 2017)

Dataset	**UCSB CHIRPS v2p0**	**SA-OBS 1.0**	**GPCC**
Min. Annual Rainfall	1871 mm	830 mm	925 mm
Max. Annual Rainfall	3062 mm	2370 mm	2530 mm
Mean Annual Rainfall	2272 mm	1348 mm	1968 mm
Standard Deviation	300 mm	340 mm	303 mm
Max. inter-annual Variability	777 mm	907 mm	1209 mm
Min. inter-annual Variability	18 mm	17 mm	8 mm

Tab.6 shows the relative frequencies of days with a certain amount of rainfall based on the SA-OBS dataset. Between the periods 1981-91 and 2003-13 the frequency of days with over 10, 20 and 30mm increased slightly. The frequency of days without rain decreased slightly between the periods. The period 2003 -13 also records the day with the highest amount of rainfall. Overall the distribution of rainfall events of different magnitude within the dataset did not change remarkably.

Tab.6: Relative frequency of days with different rainfall amounts in the study area (Ta Ang, Teurn and Seda Commune) for the period 1981-91, 1992-01 and 2003-13 (van den Besseelaar *et al.*, 2017)

Period	Days Without Rain	=<10mm	>10 and =<20mm	>20 and =<30mm	>30mm	Max
1981-91	56	33	8	2	1	83.85mm
1992-02	52	35	9	3	2	72.03mm
2003-13	52	33	9	4	2	104.29mm

The annual mean temperature in Fig.X shows an increase for the period 1981 - 2016. It varied between 23.5 °C in 1991 and 25.1 °C in 2016 during the period. A linear regression model describes the trend with $y = 0.0254x + 23.555$ and a R^2 value of 0.45, which translates into an annual increase of 0.03 °C.The average temperature over the period was 23.4 °C.

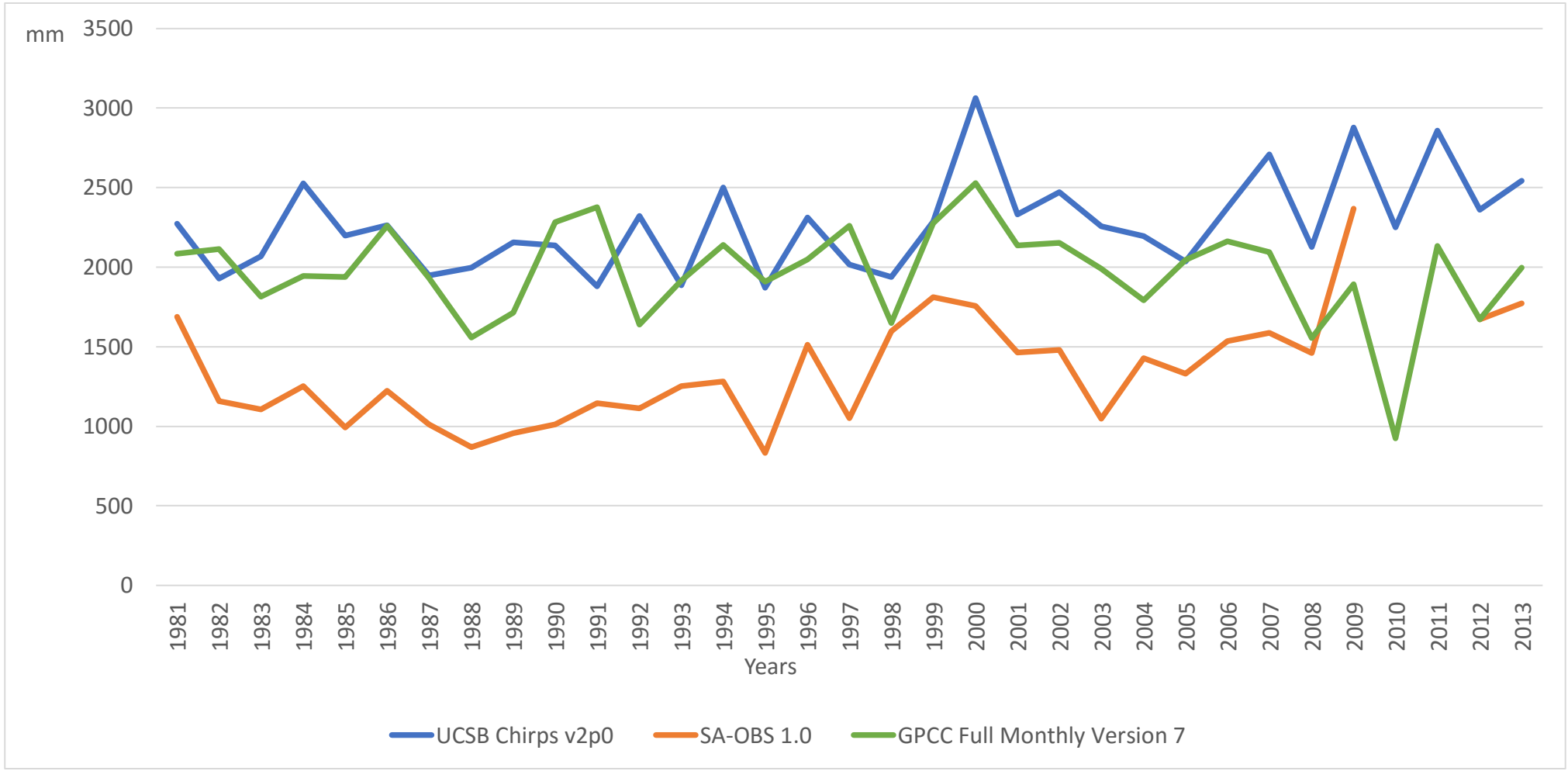


Fig.5: Total annual rainfall from 1981 – 2013 based on different datasets averaged over the study area (Data from Funk *et al.*, 2014; Schneider *et al.*, 2015; van den Besseelaar *et al.*, 2017)

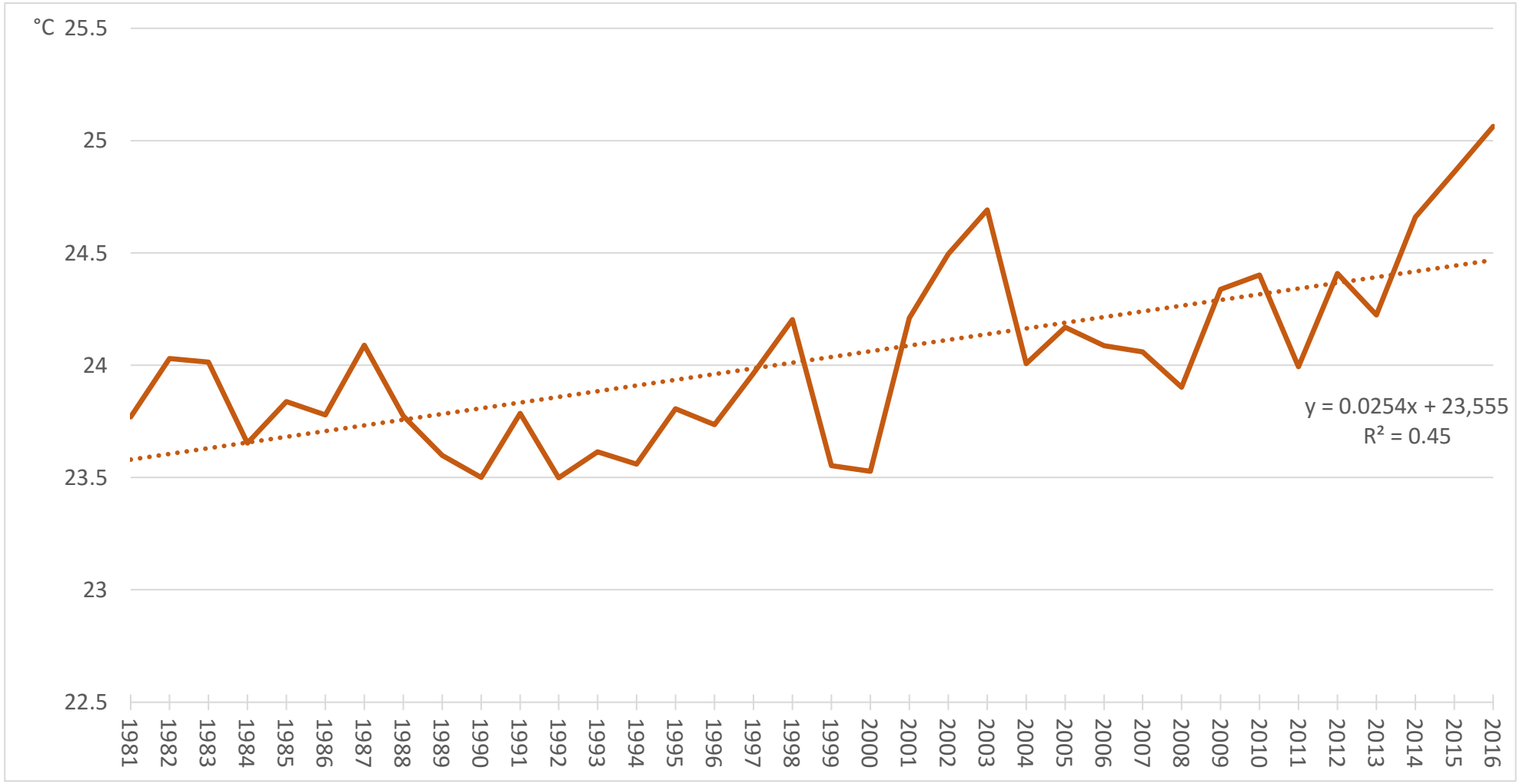


Fig.6: Annual mean temperature from 1981 – 2016 averaged over the Study Area (Ta Ang, Teurn and Seda commune in Ratanakiri, Cambodia) with a linear regression model (Data from CPC, 2017)

3.1.7. The Effects of ENSO on the seasonal Climate in Koun Mom and Lumphat

In Fig.7 the dry and rainy seasons from 1981 to 2017 are plotted out against the standardized temperature (y-axis) and the standardized rainfall (x-axis). The different seasons are classified according to the magnitude of the ENSO event during the season. For both dry and wet seasons, seasons with strong El Niño events all had less than average seasonal rainfall. Overall, rainy and dry seasons with El Niño events tend to have less rainfall than seasons with La Niña events. For both seasons, there is a linear negative correlation between the average Multivariate Enso Index over the season and the seasonal rainfall. For the dry season the correlation can be described as $y = -6{,}7122x + 39{,}435$ and has a R^2 value of 0,15. For the rainy season the correlation can be described as $y = -142{,}34x + 2279{,}5$ and has a R^2 value of 0,15 as well (see Annex I for the regressions).

In terms of temperature, dry and rainy seasons with El Niño events are generally warmer than the average season and La Niña seasons are generally colder compared to each other. For the rainy season the correlation is more pronounced and can be described as $y = 0{,}1796x + 24{,}118$ with a R^2 value of 0,13. For the dry season the values show more variability and the correlation between the average seasonal MEI and the seasonal mean temperature is extremely weak with a R^2 value of 0,06. The temperatures within the dry season usually vary between December (cold) and March (hot) in the study area.

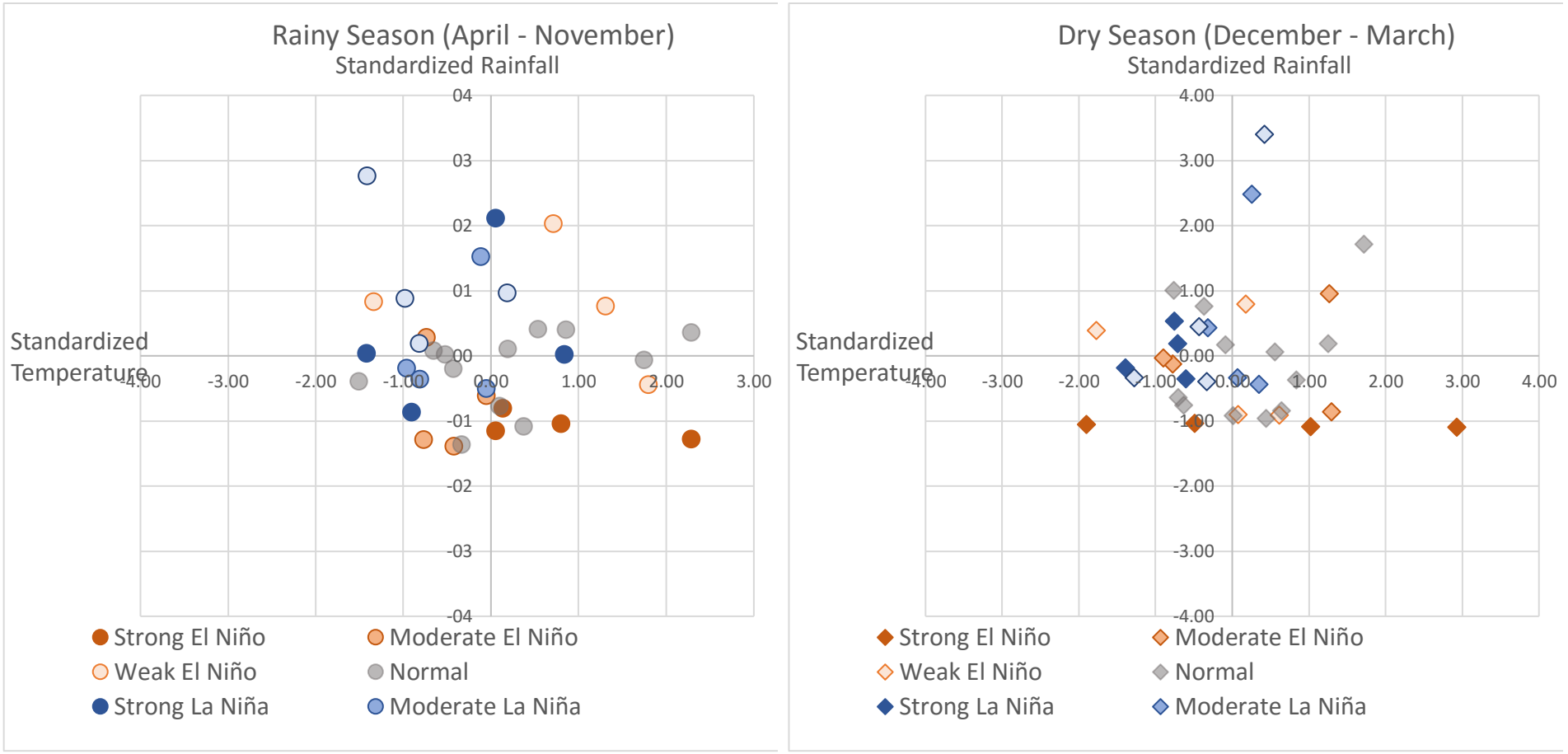


Fig.7: El Niño and La Niña seasons plotted against standardized seasonal mean temperature and standardized seasonal rainfall for the period from January 1981 till March 2017 (Data from Funk *et al.*, 2014; CPC, 2017; Wolter and Timlin, 2017)

3.2. The current state of climate information

This chapter presents the current state of climate information in the study area. First, from the end-user perspective and then the institutional set-up.

3.2.1. The current state of Access, Understanding and Use of climate information

The most frequently mentioned access channel for weather information during the FGDs was the radio. During all FGDs it was stated, that there are weather forecasts available broadcasted by the radio stations. In most cases respondents did not have direct access to a radio, but could indirectly access a radio through neighbours, friends or extended family. As a result, the access is infrequent. Some respondents used their phones as a radio receiver.

TVs came frequently up as a source of climate information as well, but here the access situation is even more problematic. Only a few households in each village own a TV and access is in most cases indirect either at coffee shops, restaurants or through social contacts. Since there are less TVs in the communities, access to it is even more infrequent and it is very often a shared medium in semi-public spaces. This brings the question of who controls it? As a young Cham man in Teurn said: "We can watch the forecast sometimes, when they switch through the channels", referring to older male members of his community.

Although the mobile phone operating companies provide a weather forecast service on the provincial level, only one young Cham women said, that she is making direct use of it. During a few other FGDs it came up, that participants know, someone, who uses the service. The service needs to be paid for. But mobile phones are used as a mean to share information about the weather, obtained from other sources. Smart phone penetration is very low and network coverage for internet access a problem in many villages. Only 2 participants used their smart phone to directly access weather information. In more cases it was said, that they can see someone sharing information in their Facebook thread, but are not actively looking for information about the weather. Navigation of the internet using the Latin alphabet and partly English language came up as barriers.

NGOs and the Agricultural Department are visiting the villages and provide occasionally training on agriculture (e.g. crafting of cashew trees, new crops). In a few FGDs groups it came up, that during these trainings, participants also learned something about the weather, although this was not the focus of the training. Both NGOs and the Agricultural Department tend to focus on the indigenous population. Awareness of the ACIS project is very low and in no FGDs the seasonal bulletin, which was developed under the project, was named as a source for climate information. If people referred to the ACIS project then through the rain gauges, which were installed during the project.

The information obtained from the described sources is mostly short term (daily and weekly forecasts and warnings). In a few cases respondents stated, that sometimes they get coarse information about a month, e.g. July will be rainy, from the radio or TV. Participants also said, that occasionally the information is combined with agricultural advice on the TV or radio, like information on planting certain fruit trees. In general people assign a high credibility to the forecasts. If the credibility was questioned it was done indirectly, the forecast was perceived either as timely or spatial inaccurate. But it was still seen as valid. E.g. The forecast has been for the whole of Ratanakiri, hence participants were still sure it was accurate for another area in Ratanakiri.

Beside the weather forecasts, people rely primarily on direct observations of the sky. There are also various indigenous forecast techniques employed by the indigenous population but also used by a Khmer community, which has been living in the area since the Khmer rouge period (1975-79). Most prominent is the reading of a lizard tail, where the extend of black color segments provides an estimate of the duration of the rainy season and rainfall distribution during the season. Other techniques are based on the flowering of certain tree species, the behavior of ants and the location of forest chicken nests. The indigenous techniques are perceived as highly credible among the groups, who practice them and are carried out by both men and women. They provide information which is regarded as valid. One women group also referred to people, who can dream about the weather and base forecasts on these dreams.

The most important use to which all respondent groups referred is human safety. Storm warnings and announcement of heavy rainfalls are usually shared within communities. So, people know when to be careful, not to go to the forest and to deny their children to leave the village. For this purpose, the mobile phone is used as a way of sharing information. If respondent groups mentioned the use of climate information for agriculture, they referred to land preparation and timing of planting or harvesting. No participant mentioned the use of a

seasonal forecast for the overall seasonal planning or crop choices. Information from forecasts are combined with direct observations and information obtained from indigenous techniques.

3.2.2. Barriers in Accessing and Understanding Climate information

Currently all climate information services farmers in the study area have access to require a certain level of Khmer proficiency. Not everybody in the study area speaks Khmer. As one older women group in Pom explained referring to the radio "We understand the words, but we don't understand what they mean". Some of the services like the ACIS Project bulletin and mobile phone services require that the users are literate. Overall most of the respondents showed problems to handle information which is abstract and alien to their world of experience. The rain gauges, which were installed in the villages facilitated the communication about rainfall amounts by providing a reference. Frequently participants overestimated the capacity of the rain gauges beyond the recording of rainfall data and believed that it will provide them with accurate forecasts and flood warnings.

Looking at the education level divided among gender and age groups as a proxy for language and literacy proficiency and ability to handle abstract information in Fig.8 indicates that there is a share in all age and gender groups, who does not have any formal education. Particularly women above 30 years, where almost 60% of the women do not have any formal education stand out. Also among men in the same age group the share of respondents with no formal education is relatively high.

A two-way ANOVA was conducted to examine, whether these differences are significant. There was no significant interaction between the effects of gender and age on the education level ($p = 0.5$). Age was the only significant factor ($p < 0.001$). Gender proved to not be significant ($p = 0.67$).

Additionally, a one-way ANOVA was carried to test the null-hypothesis, that there is no difference in education levels between the different villages. The null-hypothesis was rejected as there was a significant difference between groups ($F(3,86)$, $p=0.003$). A post-hoc Tukey test revealed that the education level was significantly lower in Pom than in Tus (Mean difference = -3.1 years of schooling, $p=0.02$) and Teurn (-2,7 years of schooling, $p=0.02$). There was no significant difference between Tus and Teurn ($p=0.96$). Comparing indigenous and non-

indigenous groups with a one-way ANOVA did not reveal a significant difference (p=0.06) (see Annex II for the models). The use of the education level has its limitations as men tend to be more mobile, have more contact to outsiders and more opportunities to exercise their Khmer.

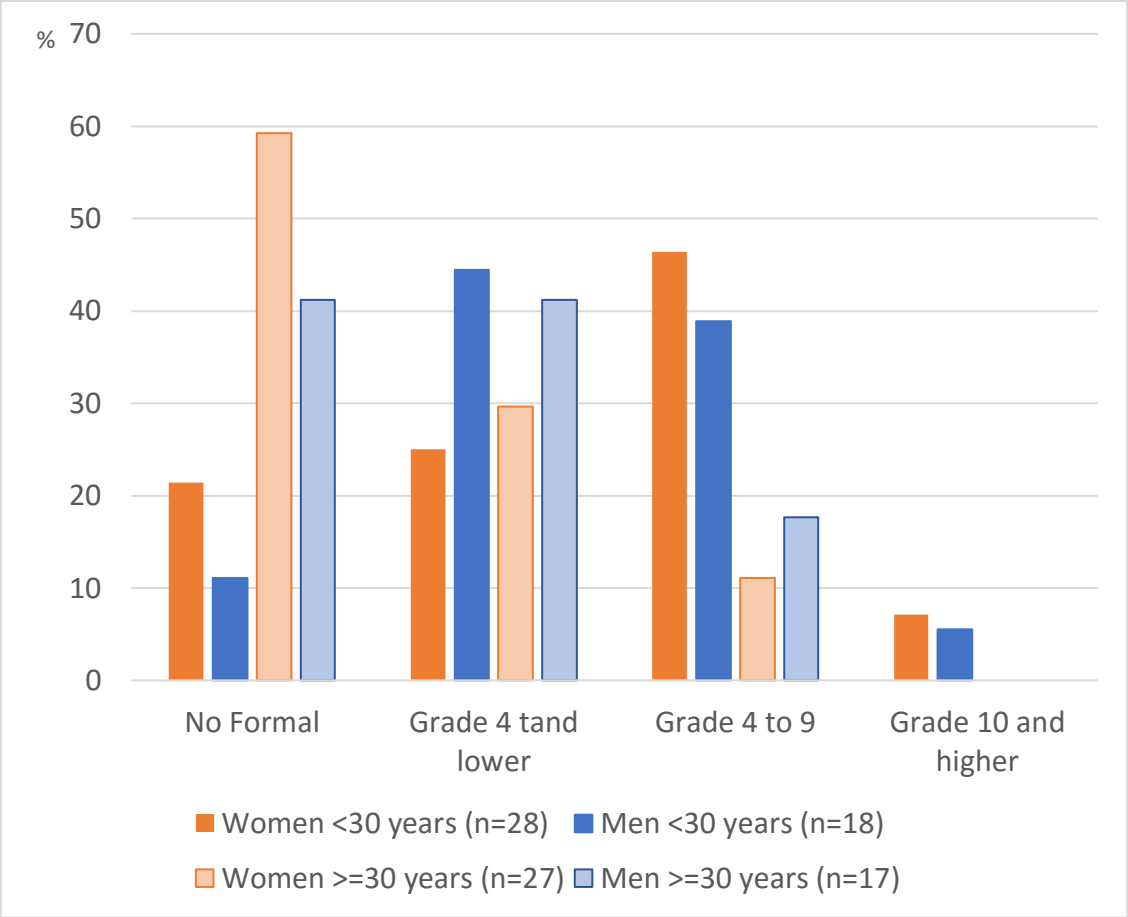


Fig.8.: Share of different education levels among different gender and age groups (Author's fieldwork)

Regarding the potential access to climate information, there is a huge difference in mobile phone ownership between men and women across all ethnic groups in the study area. 80% of the male, but only 33% of the female respondents own a mobile phone (Fig.9). The gap translates into the internet access (37% of men, 13% of women). A Logistic regression model was used to analyze the influence of gender, age and ethnicity on the likelihood that the participant owns a mobile phone. The model was significant (Chi Square = 34.31, $p < 0.0005$), explained 42.3% of the variance (Nagelkerke R^2) and classified 71.1% of the cases of mobile phone ownership correctly. Significant factors in the model were gender ($p < 0.0005$), age ($p=0.008$) and belonging to the Cham ethnic groups ($p = 0.01$). Men have significantly more

frequently mobile phones compared to women. Younger respondents and members of the Cham ethnic group own more frequently than members of the other ethnic groups (see Annex III for the model).

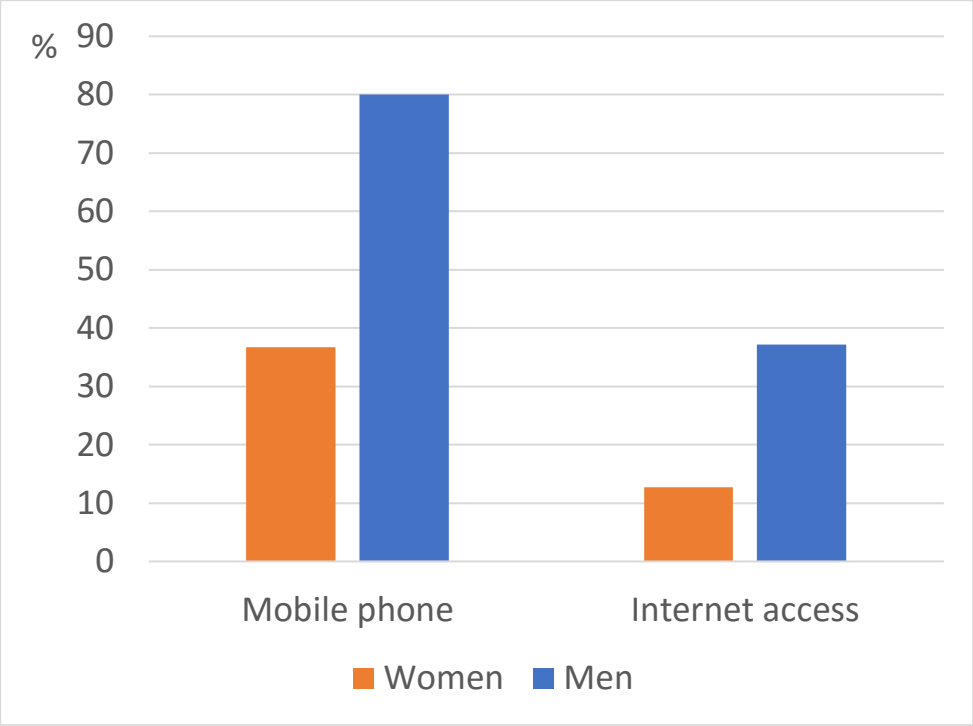


Fig.9: Share of mobile phone ownership and internet access among men and women (Author's fieldwork)

The barriers are addressed partially through information sharing among community members. As one young Khmer women in Teurn puts it "We must share the information, so that we can all be safe and we have to wish good luck to everyone". Respondents who face difficulties to understand climate information rely in many cases on a family member or friend, who can help them to translate and interpret the information.

3.2.3. The institutional set-up

On the institutional side the responsibility for forecasting and the recording of weather date lies with the Department for Water Resources and Meteorology. At the provincial level of Ratanakiri the Department employs only one staff member. In addition, the department is concerned with the management of irrigation schemes and water resources. Being directly

involved with weather forecasting and the communication of forecasts to farmers is a new development for the department at the provincial level.

The central Department of Meteorology under the Ministry of Water Resources and Meteorology provides 3-days short term forecasts at the provincial level, which is publicly accessible on its homepage. The forecasts include humidity, temperature, a weather pictogram, wind direction and wind speed, but no estimation of the rainfall amount. There is no special product provided for agricultural purposes yet. The provincial department collects climate data and reports it to the central department in Phnom Penh.

The Agricultural Department of Ratanakiri is charged with extension services. Staff members provide training to farmers, sometimes in cooperation with NGOs. In addition, the department provides support to the communes and districts in case of disease and pest outbreaks. Farmers can approach their commune, which will forward a request via the district to the department at the provincial level. In Ratanakiri the different districts have each 1 – 3 agricultural officers, which have to cover several thousand families. In Lumphat and Koun Mom two officers per district are responsible. Currently there are no subsidies provided by the Agricultural Department to farmers in Ratanakiri.

The Cooperation between the two departments has been focused around irrigation schemes. The Department for Water Resources and Meteorology requests the Agricultural Department to advice farmers to stop irrigation in case of drought events. Forecasts are not explicitly provided to the Agricultural Department, but are publicly accessible. The recorded weather data is shared between the departments. But currently it is not used directly. It is only forwarded to the central department in Phnom Penh.

3.3. Decision making and Access to Communication Channels among households

This chapter presents the results from the two decision cases and from an analysis of communication asset ownership at the HH level.

3.3.1. Paddy Transplantation and Weeding Expectations

he transplantation date for paddy rice in the sample varies between June 20 and August 16. Half of the respondents transplanted before July 17. What is considered the optimum seedling age clusters around 3 different answers: 15, 30 and 35 – 45 days (Fig.10). Most respondents (8) consider 30 days as the optimum. The argument for an early transplantation date is the fast growth rate. A late transplantation date is justified by the higher flood resistance and robustness of the seedling during the transplantation. Respondents frequently used the words big and strong to describe an older seedling. The participants who preferred 30 days use both fast growth and robustness as justification. What is considered the optimum height of water during the plot for the transplantation varies between 2 – 20 cm. There is no correlation between what respondent considered the optimum seedling age and the optimum water height in the pot during the transplantation. The soil texture of the sampled plots varies between clay over silty clay, clay loam and silty clay loam to sandy clay. No relationship between the soil texture and the transplantation date and optimum seedling age could be established.

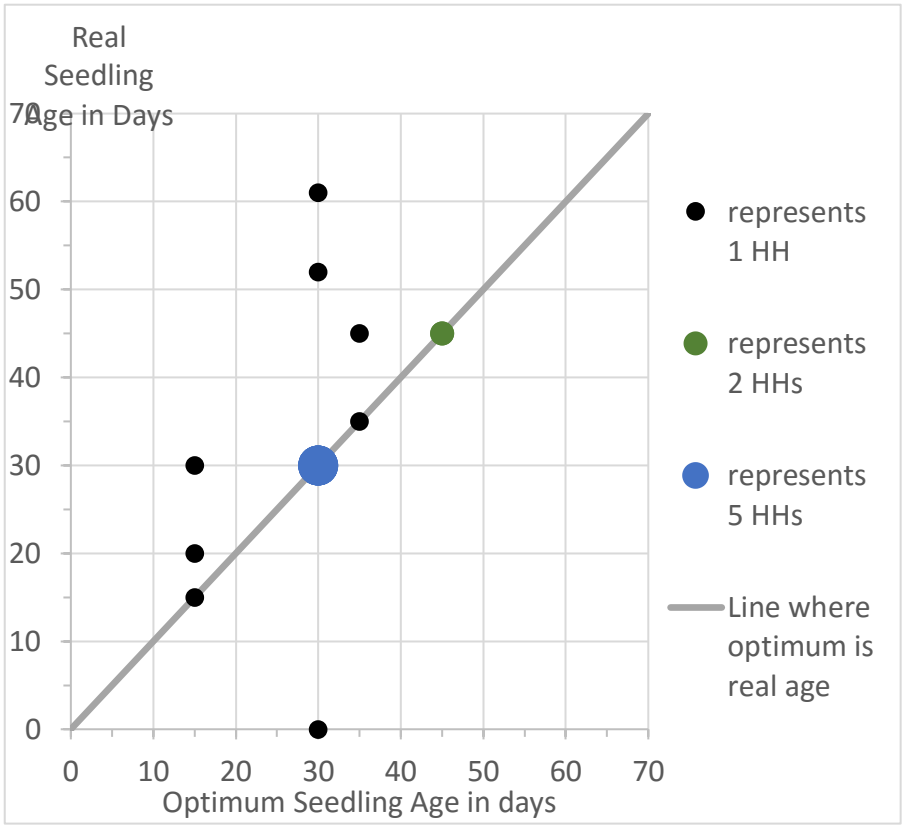


Fig.10: Optimum and real age of paddy seedlings among households (n=15) for the season 2017/18 (Author's fieldwork). The grey line indicates where optimum and real age equal each other.

Most respondents could transplant their seedlings at the considered optimum age. These are represented by the dots on the grey line (Fig.10). 5 respondents transplanted seedlings, which were older than the considered optimum age. In addition, 2 respondents stated that they transplanted to a later date that they initially wanted to. But they could already foresee it in their planning and adapted the timing of establishing the nursery, so that the seedling could be transplanted at the optimum age. The most frequent reason for delaying the transplantation was access to a hand tractor for preparing the field. All 4 households, who cited access to a hand tractor as the reason for changing their planting date did not have a relationship to someone, with a special position in the village and where not classified as wealthy. Other reasons were being occupied with other on-farm and off-farm work and cases of sickness in the household. There is one household which decided to directly seed its paddy rice by broadcasting. The respondent foresaw, that it would be difficult to find the required labour for the transplantation, since people in his village were very busy this year.

Most of the sampled households do not practice any active weed management. Only 6 of the 15 respondents stated, that they plan to weed in their paddy fields this year. No household stated to use pesticides or fertilizer in the paddy fields. But several households said that they weed and apply herbicides to their other farmland both with cash crops and Chamka rice. The 6 households, who plan to weed include the 3 households with the lowest farmland to HH member over 16 able to work ratio, as an indication of labour availability. Three of the 6 households have been classified as wealthy, 1 as neutral and 2 as poor. None of the households stated, that they plan to use hired labour or exchange labour for weeding in their paddy plots. But all households except one stated that they use labour outside the HH for other activities (e.g. planting, harvesting) either by hiring or exchange of labour.

3.3.2. Crop Choices for the Season 2017/18

Out of the 40 sample households 32 cultivated cassava during the last season (2016/17). 20 of them stated that they had problems with their cassava during the season. Most frequently participants referred to unusual off-seasonal rainfalls interfering with the drying as one of the reasons. This came up during 19 interviews and was in addition also mentioned by a few respondents, who expressed that they could finish on time, but that other households were affected. Results were losses in quantity as well as a lower quality of the cassava. In general

respondents complained about the low prices for both soybean and cassava. The price obtained for cassava ranged from 0,03 $/kg to 0,13 $/kg and depended on the quality and the timing of the harvest. The price is high at the beginning of harvesting period in December and January and decreases towards April. Respondents harvested their Cassava between December and April. The respondents who indicated the latest harvest dates in March and April also indicated a relatively low price. In a few cases participants draw a link between the low quality and the obtained prices and stated, that buyers used it as an argument to lower the price. The Price for soybean varied between 3 – 5 $/kg.

From the season 2016/17 to the season 2017/18 the total area under cassava cultivation decreased. 11 of the 40 households in the sample decreased the area with cassava and only 4 households increased it. The balance is an increase of 16.5 ha in the sample. The area under soybean cultivation in comparison was increased by 13 households and only 4 household decreased it. The balance is an increase of 25 ha. 6 Households also established new cashew plantations and only one household decreased the area of cashew, the balance in the sample is an increase of 11.5 ha.

The reasons for changing the land use varied a lot. A part of the increase in soybean is related to the simultaneous expansion of cashew since soybean is preferred over cassava as an intercrop. An increase of 7 ha in the area under soybean cultivation can be explained by this relationship. Other reasons stated for expanding soybean were the low cassava price last season, the more concentrated labour requirement, expansion of farmland, following other farmers in the community and the ability to earn money from it compared to rice. A barrier is, that soybean planting material needs to be purchased from a company and demands a higher financial investment compared to Cassava, which is propagated within the communities. This was one of the reasons mentioned by households, who increased Cassava in addition to higher production of cassava compared to soybean and expansion of farmland.

3.3.3. Household characteristics and Access to Communication Technology

Tab.7 shows the relative ownership of communication assets among households with less and with more than 5ha of farmland. All households with more than 5 ha of total farmland own a mobile phone, while only 60% of the households with less than 5 ha. Slightly more households with less than 5ha own a radio. There is no difference between the two groups regarding TVs.

The share of land under cashew cultivation is higher among the households with more than 5 ha of farmland.

Tab.7: Relative ownership of communication assets and share of cashew cultivation among households with farmland of different extent (Author's field work)

Asset	HH with < 5ha (n=20)	HH >= 5ha (n=19)
Radio	50 %	37 %
Mobile phone	60 %	100 %
TV	20 %	21 %
Share of Cashew from total farmland	25 %	49 %

A logistic regression, which links the size of farmland and the share of cashew to the ownership of the communication assets, was statistically significant (Chi square = 9.698, p-.008) for mobile phones, but not for radios and TVs. The model explains 34,5% of the variance (Nagelkerke R^2) and classifies 87.2% of the cases of mobile phone ownership correctly. The relationship between size of farmland and mobile phone ownership is statistically significant (p=0.023). Households with more farmland are more likely to own a mobile phone. There is no significant relationship between the share of cashew and mobile phone ownership (see Annex IV for the model).

3.4. Designing climate information products

This chapter will first outline the results from the scoring on the communication preferences and from the participatory development of forecast products.

3.4.1. Communication Preferences and Needs

The communication channels for forecasts which were scored the highest on average in terms of the end-user preference were the Agricultural Department (Average Score = 4.7) and NGOs (Average Score = 4.5). Respondents value the two-way communication and the opportunity to gain new skills and knowledge. The difference was explained by some groups giving a higher credibility score to the agricultural department. Scores were reduced for time requirements and frequency of dissemination of information. The radio scores just slightly lower on average with 4.4. The high scores were based on the possibility to take the radio to the fields and that there is no need for literacy. The variability of scores among different respondent groups for the three communication channels is low.

The lowest average score was given to signpost (2.6) due to the need for literacy and the time it takes to go to the signpost and read it. Women groups were more variable in their scores for signposts than men and indigenous women indicated on average a higher preference then none-indigenous women. This may depend on the fact that indigenous groups are more familiar with signposts used by NGOs in the area and that literacy and Khmer language proficiency varies more among women compared to men.

The mobile phone was scored relatively low with an average of 3.0 but got the most variable scores, depending on the access situation and literacy level of the respondents. In some cases, participants justified a relatively high score with the ability to indirectly access a mobile phone through a household member. There is a difference in the scores between age groups regarding the mobile phone and TV. Younger respondent groups scored both channels higher on average than older respondent groups and gave more uniform scores. The difference in preference for mobile phones is particularly pronounced between women groups of different ages. Younger women scored the mobile phone on average 2 scores higher than older women.

Tab.8 summarises the arguments from the discussions around the scores. In most cases participants discussed them not only from an individual perspective, but thought about the

community as a whole and took into account that they have family member, who are able to read or own an access a certain channel. It is noteworthy, that the only advantage mentioned for signpost, was its accessibility. NGOs and Agricultural Department are combined in the table, since participants gave similar arguments. In general, they value the opportunity for interaction, direct experience and to develop their skills and knowledge. Loudspeaker, TVs and Radios have the advantage that they not rely on written language. The loudspeaker could be a way to reach members of the community, who cannot access a radio or TV and to adapt the language. But participants said, that they are not always in the villages. Particularly during the planting and harvesting, when information is needed, they spend a lot of time on their different farms. Mobile phones make it easy to share information and allow for fast dissemination, but net coverage and the correct display of Khmer fonts are considered as a problem.

Tab.8: Advantages and disadvantages of different communication channels from the end-user perspective (Author's fieldwork)

	Advantage	Disadvantage
Radio	• Mobility • Audio (literacy not required) • Information is up-to date • Phones can be used as a receiver	• Requires access to radio • No visual communication • Not always time to listen • Need to speak Khmer
TV	• Visual and Audio • Time is flexible	• Not always time to watch • Requires access to TV • Signal is disturbed during storms and lightening • Need to speak Khmer
NGO and Agricultural Department	• Interaction and possibility to ask questions • Capacity building • High Credibility (particularly Agricultural Department) • Direct experience	• Participation is time intensive • Not frequent • Slow dissemination of information • Lower credibility of NGOs, since they focus on many topics
Signpost	• Publicly accessible	• Lack of interest in signposts among farmers • Takes time to go and read • Farmers need to be made aware of the existence and location • Need for literacy • Not suitable for every day information
Mobile Phone	• Fast dissemination of information • Ringing calls attention • Easy to share the information • Mobility	• Net coverage varies • Requires Literacy • Access to Mobile Phone • People could disregard it as advertisement • Problems with Khmer font • Cannot be used during storms and lightening
Loudspeaker	• Can be combined with a radio to broadcast information • Broad reach • Language can be adapted • Audio	• Can only reach people who are in the village • Difficulties to understand (People talk fast and unclear) • Low credibility since information is from the villagers • Needs collective action for financing the energy supply

3.4.2. Participatory Design of Forecast Products

Participants in all the workshops expressed the need for information about days with rain and no rain and an indication of amounts in a day-by-day format. This could facilitate concrete decision making during the land preparation, planting and harvesting period, e.g. for the planting of soybean, which is preferably planted after rain in a window of days with no or low rainfall.

In Pom discussions focused on the similarities between indigenous and technical forecast techniques and the knowledge, which can be obtained from these techniques. Participants acknowledged that both techniques deal with uncertainties as they both try to predict the future. Concerns were expressed about the spatial accuracy of technical forecasts. Towards the end a seasonal outlook with month by month information and pictograms was discussed. Discussions about a potential forecast product centred on bulletins, since a loud speaker system had been absent from the village and facilities for radio broadcasting were not accessible.

In Tus, particularly the male participants were curious about the science behind climate variability and asked questions about its reasons. The group was very dominated by its male members, who held official positions and seemed to be more familiar with abstract thinking. The female champion farmer appeared very tired. The author tried unsuccessfully to slow discussions down and to invite the two female participants to contribute. The group discussed the possibility to organise meetings to share information within their community also to members, who do not have access to TVs and radio. One male participant described the idea to use graphic illustrations during the meetings to train and share information to some community members, who then can use the same pictures to share the information with the rest of the community. The other participants confirmed the importance of visual inputs in the communication of weather forecasts, since letters and numbers are difficult to understand for many community members. Visual depictions should cover sun, cloudy and different types of rain. Participants asked for location specific information at least at the level of the commune. Pictures can be displayed at the meeting house and villagers can explain them to each other. One participant estimated that 80% of the villagers would be able to understand them correctly. Loudspeaker and a community radio station were discussed as another option to spread

information to the villagers. Currently the village does not have a loudspeaker installed and funds would be needed for its maintenance.

In Teurn one male participant described the idea of a mobile loudspeaker inspired by the recent election period to share information. The village chief suggested to address the Department of Water Resources and Meteorology for information which could be distributed via the loudspeaker. The loudspeaker was evaluated as a time efficient medium. Participants acknowledged the uncertainties attached to forecasts. The Department of Water Resources and Meteorology was seen as very skilled in making forecasts. Participants developed together with the author a day by day format including a pictogram, temperatures and rainfall amount (see Fig.11). DD Month YYY was chosen by the participants as the common format for dates. Dividing the days in different time segments was discussed and some participants expressed concerns, that it would complicate the format and that the focus should be on a simple visual expression. The group wanted to explore the idea of a weekly forecast.

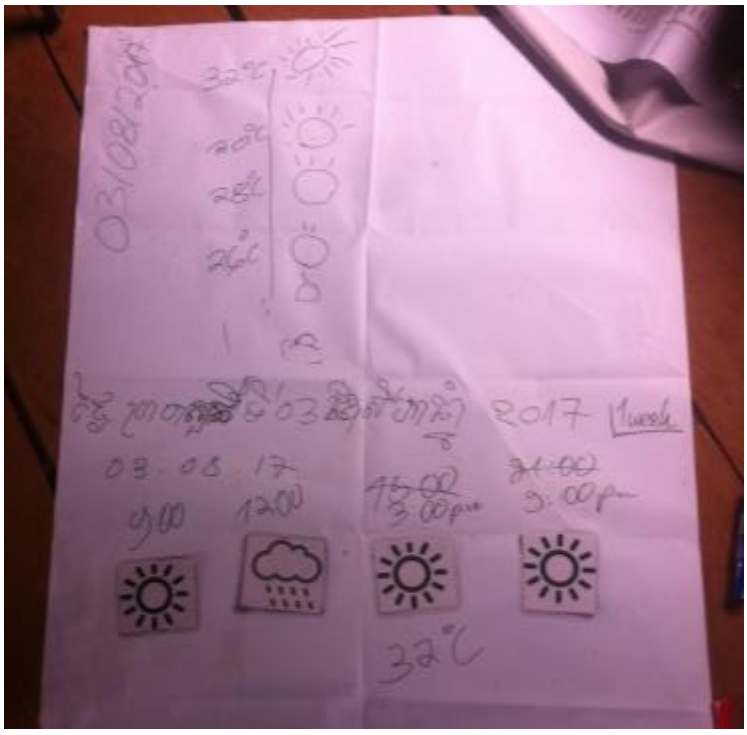


Fig.11: Forecast format idea developed during a participatory workshop in Teurn (Author's fieldwork)

Understanding the forecasts from the Department of Meteorology proved difficult in Pom and Tus. In Pom participants were unfamiliar with the format. They could describe the pictograms but were unable to connect them to the forecasting period. For example: It was clear that the pictogram depicts rain, but it was unclear to which day it refers. In Tus the participants understood the numbers for wind speed as the month and for temperatures as the day. After this was clarified, most of the participants interpreted temperatures correctly. An illiterate participant could only interpret the pictograms without relating them to the forecasting period or to make sense out of the numbers. In Teurn participants could correctly identify that a °C indicates temperatures, but lacked the reference frame to interpret them correctly. After the temperature for today was looked up on the mobile phone, participants connected the number of 32 °C to the feeling of very hot. In this group too an illiterate participants had difficulties to follow the discussions on the temperature scale. The characteristics of the developed forecast format are summarised in Tab.9 and the examples are attached in Annex V.

In Pom and Tus the feedback groups selected the monthly format to test in their communities. In Teurn the groups selected both the monthly format and the 3 months' outlook. The weekly format was perceived as overwhelming and complicated. In Pom, the bulletin was displayed inside the meeting house and in Tus on the outside of the meeting house. This was justified with the accessibility and the possibility to hold meetings about it. In Teurn the group decided to hand the bulletin the village chief, who will display it at his house. The reason, was increased protection in case of rainfalls. The group also proposed to have the bulletin printed on a rain resistant material or to provide a protective structure.

All three groups preferred premade drawings over premade pictograms. In Pom participants had difficulties to understand a drawing for storm, since they were confused by the sun, which was depicted as well. It was suggested to leave the sun out. The picture, which was supposed to depict no rain, was wrongly interpreted by all groups as a strong sun, since the sun was placed to prominently and drawn out of proportion. The drawings, which intended to show high and low temperatures, did not prove to be understandable to the participants in all three villages. Some of the participants in each group needed a short explanation to be able to interpret the colour scales correctly, others had a more intuitive understanding of it.

Tab.9: Characteristics of tested forecast formats (Author's fieldwork)

	Bulletin A	Bulletin B	Bulletin C	Text message
Communication Channel	Sign Post	Sign Post	Sign Post	Mobile Phone
Forecasting Period	1 week	1 month	3 months	3 days
Format	Day by day 1st to 3rd day divided in afternoon, morning and night	Day by day	Month by month	Day by Day
Forecasting Source	1st-3rd day: Windity 4th -7th day: Accuweather	Meteoblue Accuweather	Accuweather	Meteoblue
Spatial reference	District Capital	District Capital	District Capital	Commune Level
Information	1st-3rd day; Rainfall amount in mm + average Temperature in °C 4th-7th day: Rainfall in mm + minimum and maximum temperature in °C	Rainfall amount in mm	Rainfall amount in mm Min. + max. temperatures in °C	Rainfall amount in mm Average Temperature
Illustrations	Yes	Yes	Yes	No
Colour Scales	Yes	Yes	Yes	No
Written Descriptions	No	No	No	Yes

The participants in Pom suggested to include a verbal description of rainfall amounts, which was supported by the other groups, when proposed. The participants in Teurn asked to include temperature in the monthly format. The group in Tus supported the idea. Participants in all villages could relate the rainfall amounts in mm to the rain gauges, but seemed to lack a reference frame. in order to interpret them correctly. E.g. What does 10mm of rainfall mean? The champion farmers were more advanced on interpreting the rainfall values and gave explanations to the other group members.

The text message proved to be receivable and was correctly displayed in most cases. One of the champion farmers did not receive the message. The focal points could understand the content in terms of forecasting period, temperatures and rainfall amounts.

Box 1 – Farmers' ideas to communicate climate information

- Connect a radio to a loudspeaker system to broadcast forecasts to a wider audience
- Install a loudspeaker on a motorbike or car to bring the information to people, who are in the farms
- Stage a Dramaso (traditional theatre) to teach farmers about climate change
- Record a video and produce a DVD to teach farmers about the weather and climate
- Community radio station for dissemination of forecasts

4. Discussion

There are several limitations to the study design. Firstly, the limited spatial focus and relative small sample seizes, do not allow to generalise the results beyond the study area, but provide a case, that highlights different aspects of ACIS in an ethnically diverse context and under conditions of changing farming systems. Secondly, the reliance on a convenient sampling due to practical reasons (availability of resources and respondents), brings the risk, that groups of the population, which are disconnected from the communities were missed. This was considered during the field work and contact to different groups was established. Thirdly, the focus on paddy transplantation and crop choices as cases of decision making, might have missed factors which are crucial in other decisions. Overall did the qualitative aspects of the study design allow to explore a complex topic in a dynamic context, where many stakeholders just recently started to engage with climate information.

4.1. Land Use Change and Climate Projections

Farmers in the study area, have changed their farming systems from a diverse subsistence oriented shifting towards a cash crop oriented mono-cropping system. This trend was observed in other parts of Ratanakiri as well (Fox, Vogler and Poffenberger, 2009; Padwe, 2011; Hor, 2014; Ironside, 2015). All authors describe an agricultural expansion on forested land, which was driven by the integration of cash crops into the farming systems as Chamka plots were used for cash crops instead of left fallow. At the same time migration and economic land concessions increased the land pressure. These factors give rise to a complex dynamic which eventually leads to the degradation of forest resources. The Chamka shifting cultivation system itself, is a sustainable system and has been practiced over long periods in a stable equilibrium by the indigenous population (Bourdier, 1995; Pillot, 2007). As land availability has become a major issue in all the villages of this study, the results suggest that the agricultural expansion is reaching its limits. In response, farmers are increasing the share of cash crops by dropping the Chamka from their farming systems. Paddy rice is less affected, since it is grown on land, which is not suitable for cash crop productions.

The area under cashew and soybean cultivation increased between the seasons 2016/17 and 2017/18, while the area under cassava cultivation decreased among the sampled households. The recent price for cassava was exceptionally low in Cambodia (Sokhorng, 2017;

Vannak, 2017) while the Cashew price remained stable between 2015 and 2017 (MoC, 2016, 2017a, 2017b). Together with the occurrence of the cassava mosaic virus in Ratanakiri in 2015 (Wang *et al.*, 2016), these creates an incentive for farmers to further increase the share of Cashew in their farming systems. Since it is still unknown what caused the Cashew failure during the season 2016/17 and whether it is a persistent problem, pressure on smallholder's cashew production could increase. Currently rubber and pepper do not present viable options for smallholders and are only grown by a few households in the study area.

Between 1981 till 2016 the annual mean temperature in Ratanakiri has increased by 1°C at an annual rate of 0,03 °C. Ringler *et al.* (2017) project this trend to continue with a further increase of 2 – 4 °C till 2050, depending on the climate model. Regarding annual rainfall their projections are more diverse and range from a decrease of 400 – 200 mm to an increase of 100 – 200 mm. Based on these projections they predict adverse effects on the yields of rain fed soybean and cassava in Cambodia. An increase of temperature will result in increased evotranspiration, which will add drought stress even rainfall is not declining. Since most of the agricultural area in study site is rain-fed, reduced yields are likely under the scenarios.

Taking these trends into account the identification of suitable cashew intercropping systems for hotter and drier conditions could provide an opportunity for climate smart agricultural practices. Climate smart agriculture is based on three pillars: (1) increased productivity and income, (2) enhanced resilience of livelihoods and ecosystems and (3) reduce emissions and CO sequestration (FAO, 2013). Pineapple has been used as an intercrop for Cashew in India (Moorthy, 2015). It is a heat tolerant crop (Yamada, Hidaka and Fukamachi, 1996). Such a system could increase the income of farmers, enhance the resilience of livelihoods through diversification and store carbon, if the balance from the land-use change is positive. This would be the case in conversion from annual cash crops but not for the conversion from forested land. An assessment of the market situation and identification of suitable locations, as pineapple sensitive to flooding, will be needed.

4.2. Climate variability and it's perception

The perception of seasonal climate conditions varies widely among the respondents and is linked to the experience of specific impacts. According to Simelton *et al.* (2013) the perception of rainfall among farmers in Malawi and Botswana seemed to be confounded by changes in the

sensitivity and exposure of farming systems, resulting changes in impacts. Tversky and Kahneman (1973) argue that human beings tend to evaluate the frequency of events in relation to how easy it is to recall the event. Recent and extreme events tend to be easier remembered and are likely to get a bigger weight in our perception. It also appeared that farmers in the study area use different definition of what constitutes the onset and cessation of the rainy season. The same event might be perceived by one farmer as a normal onset followed by a drought and by another farmer as a late onset.

It is worth noting that not only farmer's perception diverged, but also the three rainfall datasets provided very different data on annual rainfall over the period 1981 till 2013. In a country, like Cambodia, where systematic recording of weather observations was not continuous and poor till the early 2000s (Phalla, 2010), the lack of reliable data imposes a serious challenge on the development and downscaling of forecast models.

4.3. Actionable Agro-Climate Information Services and End-User Groups

This chapter first discusses different aspects of potential ACIS in the context of Ratanakiri along the definition of Simelton et al. (forthcoming). According to this definition an actionable ACIS needs to be (1) accessible and (2) understandable for the end-users and provide (3) useful and (4) timely information. In addition, the capacity to translate the information into action is discussed. Eventually, a capacity based approach to characterise end-user groups and inform the design of ACIS is outlined.

4.3.1. Accessible and Understandable Agro-Climate Information Services

Currently access to climate information is in most cases infrequent and indirect among the study population. Mobile phone based services were discussed in the literature as a potential way to link farmers to different sources of information and to address information gaps (Aker, 2011; Nakasone, Torero and Minten, 2014) in a cost effective way (Etwire *et al.*, 2017). According to Mittal (2016) mobile phone based services can reduce the gap between men and women in regard to climate information, but improvement of infrastructure and capacity building are necessary to realise this potential. The results suggest that Women would be less likely to benefit from mobile phones based services as they own less frequently mobile-phones, also older or illiterate end-users would potentially be excluded. Gender and other socio-cultural

groups are not homogenous, but comprised of individuals with different capacities, who share an understanding of identity, that eventually influences their opportunities (Carr, Fleming and Kalala, 2016). According to Imam, Hossain and Saha (2017) individual factors like gender interact with technological, political, physical and financial factors in shaping access to CIS. In their study in Bangladesh they found that a gender gap is particularly prevalent in poorer households, who prioritise the household head with investments in communication technologies. Gender interacts with other socio-economic factors in mediating access and opportunities.

Mittal and Mehar (2016) describe a relationship between the socio-economic conditions of a household and the adoption of different communication sources. They found a positive correlation between the seize of landholdings and the use of modern ICTs (landline phone, mobile phone and internet) as a source of information among farmers in 5 states of India. A similar relationship is found for the study area. Households with more farmland are more likely to own a mobile phone. Under the current situation mobile phone based service in Ta Ang, Teurn and Seda would be biased towards younger men from households with good land access. The potential for mobile phone based services is likely to improve with growing access to phones in many countries of the global south. Nevertheless, marginalised groups and poorer households will continue to face barriers in accessing these services and risk to become further entrenched in their socio-economic status as they get more and more excluded from information communicated via mobile phones. Indirect access or the communication of different communication channels could facilitate the dissemination of inforamtion among these end-users.

Particularly older end-users are more likely to have no formal education and to face barriers in terms of language proficiency and literacy. The highest share with no formal education is among women over 30 years. Overall farmers in the study area are not familiar with the use of climate information and demonstrated problems to deal with abstract information like probabilities. Marx et al. (2007) showed for a case in Uganda, how retranslating statistical information into narratives and stories, that give end-users the possibility to connect it to their own experience, facilitates an intuitive understanding of probabilities. Using a card game to demonstrate probabilities during the participatory workshops of this study enabled a similar experience among participants. The ability of farmers to understand forecast can be improved, if they are integrated with traditional knowledge and their own experiences (Roncoli, 2006). In Senegal, Farmers give credibility to traditional

knowledge and scientific information at the same time (Roudier *et al.*, 2014). These was also observed during this study in Ratanakiri and traditional forecast technics provided an interface to talk about uncertainties.

Farmers from all socio-cultural groups put a high preference on NGOs and the Agricultural Department to disseminate climate information, based on the possibility to interact and gain new skills. Cases in Zimbabwe (Patt, Suarez and Gwata, 2005) and Burkina Faso (Roncoli *et al.*, 2008) demonstrate, that participation increased the likelihood of farmers to apply the forecast. But there is a risk, that farmers become overconfident in the forecast, if they took part in a training (Roncoli *et al.*, 2008) and that participatory approaches are not sensitive to underlying socio-cultural dynamics, which could marginalise certain end-user groups (Roncoli *et al.*, 2011).

4.3.2. Useful and timely Climate Information

Farmers in the study area expressed the need for day-by-day information (rainfall yes or not and an indication of amount), e.g. for choosing planting and harvesting dates. For Uganda it has been reported that farmers have a need for information regarding the specific timing of the onset of the rainy seasons, which is not addressed by the meteorologists' 3-month outlook (Waiswa, Mulumba and Isabirye 2007). Roudier *et al.*, (2014) argue based on a case in Senegal, that particularly farmers with a wider range of management options can make utilise seasonal forecasts. For a variety of cases in Africa farmers effectively responded to seasonal forecasts by changing their management practices (Patt, Suarez and Gwata, 2005; Roncoli *et al.*, 2008; Rao *et al.*, 2015). Information related to different time horizons is complementary and relevant for decisions on different time scales (Tall *et al.*, 2014). Providing seasonal forecasts in combination with short term forecast particularly during the planting and harvesting period has the potential to facilitate decision making regarding seasonal planning and crop choices as well as specific crop operations.

Making climate information useful requires that it is translated into its impacts on crops and linked to management implications (Hansen *et al.*, 2011). According to (Roncoli *et al.*, 2008) farmers need to be able to interpret, apply and evaluate climate information to make full use of it. Processes and tools that systematically integrate climate information into the decision making, like PICSA (Dorward, Clarkson and Stern, 2015), support farmers in making use of

the information. PICSA combines a livelihood self-assessment with seasonal forecasts. Such tools could be tailored to a specific agro-ecosystem.

On the supply side, Farmers' needs for accurate and time specific information over an extended period is not met by the available information. Reliable day-by-day information is only available for short-term outlooks. In Vietnam, the correct prediction of rainfall occurrence dropped under 50% for 2 of 3 tested forecast sources already for a 2-days-ahead forecast and for the 3rd one after the 3rd day (Roy, Simelton and Quinn, 2016). This gap is likely to remain as uncertainty and complexity are inherent in forecasting, the challenge then is to shorten the time it takes for the information to reach the end-users and to keep them frequently updated. A combination of mobile phones with loudspeaker is an option that can assure both fast dissemination and an extended outreach.

One of the major limitations for CIS in Ratanakiri today is the lack of institutional capacities to implement the service and the low availability of climate information. The ENSO analysis suggests, that ENSO predictions, can be used as a base for seasonal forecasts as El Niño years tend to be warmer and dryer than the average season and la Niña wetter and colder. Thirumalai *et al.* (2017) found that extreme temperatures in April are linked to the occurrence of El Niño in Southeast Asia. Rojas, Li and Cumani (2014) describe a positive correlation between El Niño and FAO's agricultural stress index in Cambodia as an index for seasonal water stress. In absence of institutional arrangements NGOs can function as knowledge brokers, producers and translators and fulfil different functions in linking smallholder farmers to climate information (Jones, Harvey and Godfrey-wood, 2016). In other situations, where technical forecasts were not available, the integration of traditional knowledge could potentially address gaps (Waiswa, Mulumba and Isabirye, 2007).

4.3.3. Capacity to Act on the Information

The cases of paddy rice transplantation and crop choices show that households in the study area face a variety of constraints in taking actions they desire and eventually to translate climate information into action. These constraints are based on the household's access to land, labour, physical and financial capital. According to Patt, Suarez and Gwata (2005) climate information on itself was beneficial to farmers in Zimbabwe independent of their control over resources. In West Africa on the contrary, farmers are limited in the utilisation of forecast by their low

resource endowment (Traore *et al.*, 2007). In Senegal Mertz *et al.* (2009) found that access to agricultural inputs, which is linked to the political economy, are the main constraints for farmer's decision making in face of climate variability. Carr and Onzere (2017) argue that, the potential to benefit from available and useful climate information in Southern Mali was limited by the access to productive assets like equipment and animal traction and that climate information services need to be sensitive to material as well as socio-cultural aspects of livelihoods.

In the livelihood literature access to natural, physical, financial, social and human capital has been emphasised as crucial for households to achieve desired outputs (Bebbington, 1999) and adapt to environmental changes (McDowell and Hess, 2012). Access as the *ability to derive benefits from things* depends on the position of the household within the socio-economic context, the utilisation of bundles of power and is mediated by institutions (Ribot and Peluso, 2003). This suggests together with the results from the study, that households and individuals, who are marginalised within their communities, face higher barriers to translate climate information into action because they cannot access the assets they need for doing so.

Currently the adaptive capacities among smallholders in general are very low in Ratanakiri, as they lack awareness of adaptive measures and do not experience themselves as agents. In other parts of Cambodia, like the north-west, farmers had awareness of adaptive measures, but were reluctant to implement them (Touch *et al.*, 2016). Meijer *et al.* (2015) argue that internal factors like perception, knowledge and attitude interact with external factors, like the socio-economic and environmental conditions in the process of adopting a new agricultural practice. Capacity building deals with external as well as internal factors like self-confidence (Fowler and Ubels, 2010). It will be a challenge for agro-climate information services to enable an experience of choice among the end-users, and eventually empower them. In order to do so, the implementer of the services have to engage with self-limiting beliefs and attitudes and enable experiences of choice, which will eventually empower the end-users. In situation of social exclusion like in Ratanakiri, where a group has been portrayed as inferior compared to the mainstream culture (Ruohomaki, 2003), this seems particularly relevant.

4.2.3 A Capacity Focus for Agro-climate Information Services

The communities in the study area are not homogenous. Households and individuals have different capacities to (1) access, (2) understand and eventually (3) act on climate information depending on their socio-economic characteristics. These capacities are interlinked, e.g. a wealthier household is more likely to have (1) better access and (3) a higher capacity to act on the information. According to Archer (2003) end-user groups are potentially marginalised by a climate information service, if their characteristics are not considered. Providing only (1) access to information will potentially marginalise end-users, who cannot (2) understand and (3) act on the information. A capacity based approach to characterise end-user groups can be used to guide support effectively and customise ACIS.

Table X provides an overview about different approaches that have been used in the design ACIS to increase their action ability grouped according to the capacity they address. To improve the access situation, the integration of community members into the dissemination of forecasts (Roncoli *et al.*, 2008) and the combination of different communication channels (Tall, Davis and Agrawal, 2014) present options. Translating probabilities into analogies (Suarez and Patt, 2004) and connect them to personal experiences (Marx *et al.*, 2007) and the use of local languages (Tall, Davis and Agrawal, 2014) can facilitate the understanding of forecasts. PICSA (Dorward, Clarkson and Stern, 2015) and the Participatory Scenario Process (CARE, 2013) support farmers to interpret forecasts and translate them in concrete farm management decisions. Face to face interaction either with an extension officers (Etwire *et al.*, 2017) or during workshops (Patt, Suarez and Gwata, 2005) was shown to increase the likelihood that farmers apply the forecasts.

Tab.10.: Approaches and methods to increase the actionability of agro-climate information services (references in table)

Focus	Reference	Location	Mechanism	Description
Access	Roncoli *et al.* (2008)	Burkina Faso	Participatory Dissemination	Focal points distribute forecasts to their communities
	Tall, Davis and Agrawal (2014)	Mali, India	Combining different communication channels	Combining traditional communication channels with ICTs has the potential to reach farmers at scale
Understanding	Dorward, Clarkson and Stern (2015)	Sub-Saharan Africa	Participatory Integrated Climate Service for Agriculture	Climate information is integrated with a livelihood self-assessment
	(CARE, 2013)	Sub-Saharan Africa	Participatory Scenario Process	Participatory development of different seasonal weather scenarios and crop recommendations. Scenarios are interpreted collectively
	Marx *et al.* (2007)	n.a.	Retranslating probabilities into personal experiences	Retranslation of probabilities into personal experience can facilitate an intuitive understanding of probabilities
	Suarez and Patt (2004)	Zimbabwe	Analogies	Analogies from other domains were uncertainties are experienced (e.g. sports) helped participants to interpret the probabilistic nature of forecasts
	Patt, Suarez and Gwata (2005)	Zimbabwe	Participatory Workshops	Participation in interactive workshops increased the likelihood of farmers to apply forecasts
	Etwire *et al.* (2017)	Ghana	Combination of mobile phone based forecasts with face-to-face extension	Farmers who accessed face-to-face extension were more likely to use mobile-phone based forecasts
	Tall, Davis and Agrawal (2014)	Uganda	Translating forecasts into local languages	Dissemination in local languages enhances the understanding

4.3 Trade-offs in the Design of Agro-climate Advisories

The developed and tested forecast products should be considered as examples, that illustrate the end-user needs and requirements. They allowed for an exploration of different design aspects and gave concrete entry points to conversation with the communities. But they need to be considered critically as they take a forecast period, which is too long to provide reliable information and run the risk to give a false impression of certainty to the end-users. Such an impression can potentially confuse the end-users. Choosing a bulletin as the communication channel was a practical choice, which was based on the current access situation to ICTs among the communities, questions of translations, time and resources available.

The underlying day-by-day building block of the developed forecast formats can be used to design products with much shorter forecast periods e.g. 3-day outlooks and the format can be transferred to other communication channels like a smart-phone app. Overall the process helped to understand the development of forecast products as an act of balancing different trade-offs. There are three trade-offs which were identified during the participatory design of forecast products and can be transferred to other situations.

(1) Easy to understand vs. depth of information conveyed

Structuring forecast products around a simple principle and reducing the information included in the product potentially makes them easier to understand, but it also decreases the depth of information. The product runs the risk to become too generic to be useful for farmers. One way to target this, is to think about a forecast products as a process, which starts with a very simple format, but grows more complex over time. This gives the end-users the opportunity to familiarise with the complexity of information and learn to interpret the information step-by-step.

Box 2 – Ways to Encode Information

Engaging with communities, where a significant share of the population is not literate, requires the use of spoken language, sounds and visualisation in the forecast products. There are several design elements, that can be used to convey information, e.g. drawings, pictograms and colour scales (see Tab). An intuitive understanding cannot be assumed. Pictograms can be very challenging to interpret for communities, who are not familiar with the abstraction involved (Fuglesang, 1982). Another question is to calibrate scales to meaningful references in the perception of end-users. E.g. If a categorical scale of light, medium and heavy rainfall is used, the question arises, where is the meaningful distinction for the end-users.

Tab: Design Elements for visual and audial forecast products (Author)

Medium	Design Elements
Visual	Numbers, written descriptions, drawings, pictograms, colours
Audio	Numbers, spoken descriptions, sounds

(2) Providing timely and location specific information vs. costs and time

Given farmers' needs for timely and location specific information combined with the short time horizon such information is reliable requires that the information is constantly updated and timely disseminated to the end users. This implies costs and time spent for creating and distributing them depending on the communication channel, which is used for the dissemination. In case of bulletins, they need to be prepared and distributed to the communities, where they are displayed. Using the same forecast for a larger geographical area and update them less frequently can potentially decrease costs. In case of a mobile phone based services, the question arises, who will pay for the costs of sending the forecasts.

(3) The precision of the forecast vs. the accuracy of the forecast

Precision and accuracy are two distinct criteria of a measurement. Precision describes how close measurements are to each other, while accuracy describes how close they are to the real value. To transfer the concepts to forecast products: A precise forecast product gives exact values, while an accurate forecast product is close to the real value. Given the uncertainties involved in forecasting, a precise forecast risked being less accurate. E.g. To include a precise number for daily rainfall is likely to be less accurate compared to a rainfall range, which is less precise but more likely to be accurate.

5. Conclusions and Recommendations

1. The agricultural landscape in Ratanakiri has been changing: the traditional subsistence cropping system – Chamka is disappearing as farmers increase the share of cash crops particularly cashew in their farming system. Most cropping systems in the area are rain fed and dependent on seasonal rainfall patterns, sensitive to drought stress and affected by inter-annual variability. A projected increase in water stress due to an additional increase in temperatures and possibly less rainfall is very likely to affect yields negatively. Identifying cashew agroforestry systems, with suitable heat and drought tolerant intercrops presents an opportunity for climate smart agriculture in the area.

2. The seasonal rainfall conditions show a high inter-annual variability. The perception of seasonal factors varies widely among farmers and there is no systematic difference between different socio-cultural groups. Individual experiences of impacts tend to have a high influence on the perception. But also, the three-analysed rainfall dataset diverge remarkably in annual rainfall. In a context, where reliable historical climate data is not available. Systematic evaluation of indigenous knowledge and indicators could provide an opportunity for forecasting.

3. Households and individuals in the study area have different capacities to access, understand and act on climate information related to their socio-economic conditions. Gender, age, ethnicity and wealth are factors which influence an individual's position in the socio-economic context. Using a capacity based approach to characterise end-user groups can guide targeted support and capacity building efforts. One of the core

challenges for such efforts will be to enable farmers to experience choices regarding weather and climate variability.

4. The capacity to carry out desired actions and eventually to translate climate information into actions is constraint by the access to financial, physical, natural, social and human capital. Further research is needed to identify synergies, which could arise from combining agro-climate information services with other support and integrate them with a wider system of extension services (e.g. access to credits, input supply), in order to help end-users translate information into action.

5. A major limitation for ACIS in Ratanakiri is the lack of available climate information and the low capacities on the institutional side to generate and disseminate such information. A combination of seasonal forecast with short-term forecasts particularly during harvesting and planting has the potential to facilitate decision making at the farm level. ENSO predictions can be used to inform seasonal forecasts. Regarding short-term forecast the major challenge is the timely dissemination and frequent updating. Mobile phones combined with other communication channels (e.g. loudspeakers) have the potential to assure fast dissemination and a wider outreach.

6. Designing forecast products is an act of balancing trade-off as there is no perfect design. The objective and the targeted end-users, will eventually inform the design and the trade-offs need to be adjusted to the specific situation. Engaging with communities, who are unexperienced with climate information, requires that forecast products are simple and easy to understand. Such products can grow more complex over time, as the end-user learn to interpret and apply the information.

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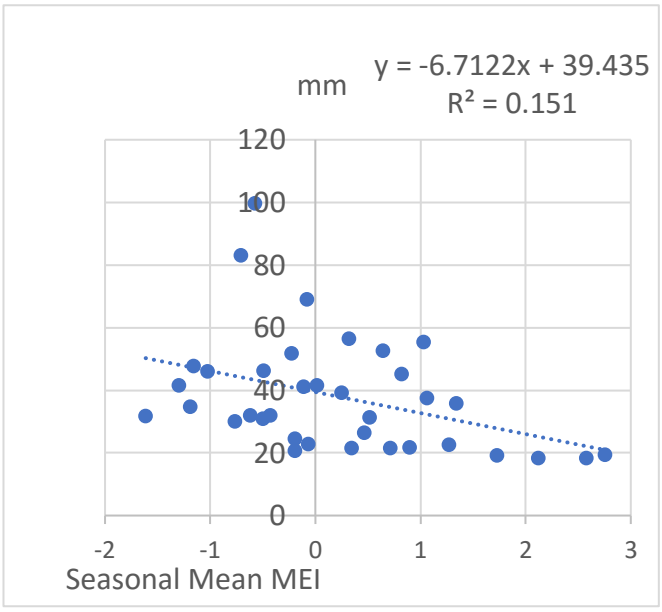
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Annex

Annex I – Linear Regressions ENSO



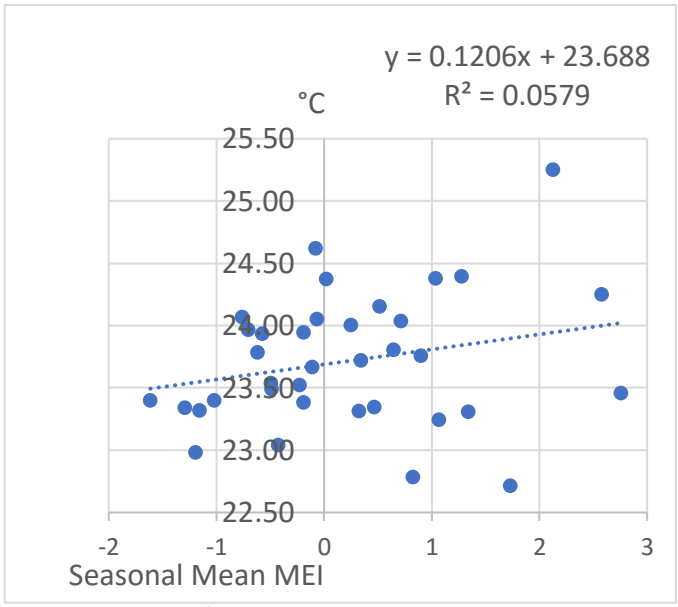
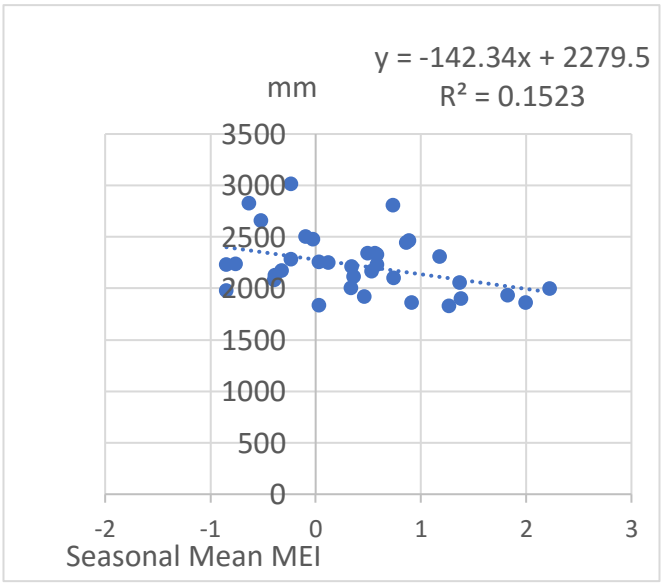


Fig.: Regression Models Dry Season (Dec-Mar). Linear regression of seasonal meanMEI with seasonal rainfall and seasonal mean temp for the period 1981-2016 (Data from Funk *et al.*, 2014; CPC, 2017; Wolter and Timlin, 2017)



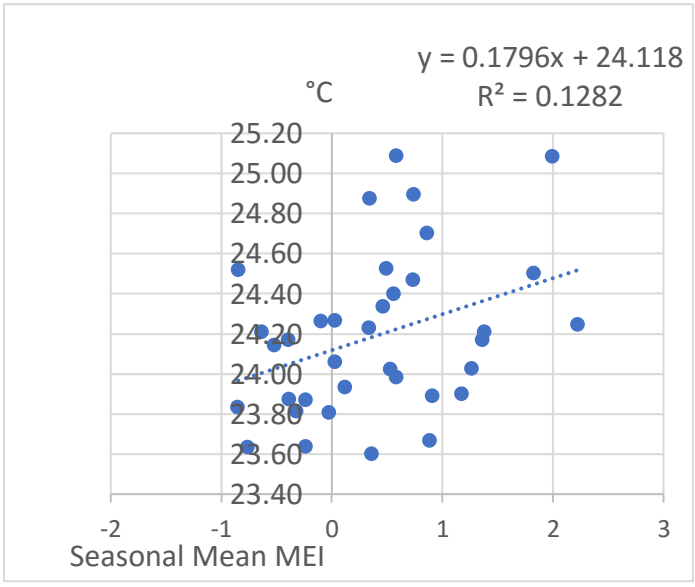


Fig.: Regression Models Rainy Season. Linear regression of seasonal mean MEI with seasonal rainfall and seasonal mean temperature for the period 1981-2016 (Data from Funk *et al.*, 2014; CPC, 2017; Wolter and Timlin, 2017).

Annex II – ANOVA Outputs

1. Two Way ANOVA - Gender * Age

H0 = No Difference between gender and age groups and no interaction between the factors

Between-Subjects Factors

		N
Gender	f	55
	m	35
Age_group	<30	46
	>=30	44

Tests of Between-Subjects Effects

Dependent Variable: Eduction

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	190.998[a]	3	63.666	6.240	.001
Intercept	1068.530	1	1068.530	104.734	.000
Gender	1.829	1	1.829	.179	.673
Age_group	163.192	1	163.192	15.996	.000
Gender * Age_group	4.506	1	4.506	.442	.508
Error	877.402	86	10.202		
Total	2192.000	90			
Corrected Total	1068.400	89			

a. R Squared = .179 (Adjusted R Squared = .150)

Estimated Marginal Errors

1. Gender

Dependent Variable: Eduction

Gender	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
f	3.389	.431	2.533	4.245
m	3.681	.540	2.608	4.755

2. Age_group

Dependent Variable: Eduction

Age_group	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
<30	4.917	.482	3.958	5.876
>=30	2.154	.494	1.171	3.137

2. One-Way ANOVA – Location

Dummy coding Location:

0 = Pom
1 = Teurn
2 = Tus
3 = Sec

H0 = No difference between locations

Descriptives

Eduction

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Minimum	Maximum
.00	21	1.5238	2.44170	.53282	.4124	2.6353	.00	9.00
1.00	47	4.1915	3.17352	.46291	3.2597	5.1233	.00	10.00
2.00	19	4.6316	4.25846	.97696	2.5791	6.6841	.00	12.00
3.00	3	.3333	.57735	.33333	-1.1009	1.7676	.00	1.00
Total	90	3.5333	3.46475	.36522	2.8077	4.2590	.00	12.00

ANOVA

Eduction

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	158.798	3	52.933	5.005	.003
Within Groups	909.602	86	10.577		
Total	1068.400	89			

Multiple Comparisons

Dependent Variable: Eduction

Tukey HSD

(I) Location_Dummy	(J) Location_Dummy	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
.00	1.00	-2.66768*	.85364	.013	-4.9042	-.4312
	2.00	-3.10777*	1.02972	.017	-5.8056	-.4099
	3.00	1.19048	2.00730	.934	-4.0686	6.4496
1.00	.00	2.66768*	.85364	.013	.4312	4.9042
	2.00	-.44009	.88414	.959	-2.7565	1.8764
	3.00	3.85816	1.93665	.199	-1.2158	8.9322
2.00	.00	3.10777*	1.02972	.017	.4099	5.8056
	1.00	.44009	.88414	.959	-1.8764	2.7565
	3.00	4.29825	2.02046	.153	-.9953	9.5918
3.00	.00	-1.19048	2.00730	.934	-6.4496	4.0686
	1.00	-3.85816	1.93665	.199	-8.9322	1.2158
	2.00	-4.29825	2.02046	.153	-9.5918	.9953

*. The mean difference is significant at the 0.05 level.

3. One-Way Anova – Indigenous and None-Indigenous

H0= No difference between indigenous and none-indigenous groups.

ANOVA

Eduction

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	43.448	1	43.448	3.730	.057
Within Groups	1024.952	88	11.647		
Total	1068.400	89			

Omnibus Tests of Model Coefficients

		Chi-square	df	Sig.
Step 1	Step	34.308	5	.000
	Block	34.308	5	.000
	Model	34.308	5	.000

Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	90.414[a]	.317	.423

a. Estimation terminated at iteration number 5 because parameter estimates changed by less than .001.

Classification Table[a]

		Predicted		
		Mobilephone	Percentage Correct	
	Observed	.00	1.00	
Step 1	Mobilephone	.00	32	12	72.7
		1.00	14	32	69.6
	Overall Percentage			71.1	

a. The cut value is .500

Categorical Variables Codings

			Parameter coding		
		Frequency	(1)	(2)	(3)
Ethnicity	CH	15	1.000	.000	.000
	KH	17	.000	1.000	.000
	KR	37	.000	.000	1.000
	TP	21	.000	.000	.000
Gender	f	55	1.000		
	m	35	.000		

Variables in the Equation

		B	S.E.	Wald	df	Sig.	Exp(B)
Step 1[a]	Age	-.047	.018	7.022	1	.008	.954
	Gender(1)	-2.828	.663	18.205	1	.000	.059
	Ethnicity			6.777	3	.079	
	Ethnicity(1)	2.455	.959	6.558	1	.010	11.641
	Ethnicity(2)	1.224	.833	2.158	1	.142	3.401
	Ethnicity(3)	.816	.690	1.400	1	.237	2.262
	Constant	2.566	.931	7.601	1	.006	13.018

a. Variable(s) entered on step 1: Age, Gender, Ethnicity.

Annex IV – Logistic Regression – Land and Communication Assets

1. Mobile Phones

Omnibus Tests of Model Coefficients

		Chi-square	df	Sig.
Step 1	Step	9.698	2	.008
	Block	9.698	2	.008
	Model	9.698	2	.008

Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	29.881[a]	.220	.345

a. Estimation terminated at iteration number 6 because parameter estimates changed by less than .001.

Classification Table[a]

		Predicted			
		Mobilephone	Percentage Correct		
	Observed	.00	1.00		
Step 1	Mobilephone	.00	4	4	50.0
		1.00	1	30	96.8
	Overall Percentage			87.2	

a. The cut value is .500

Variables in the Equation

	B	S.E.	Wald	df	Sig.	Exp(B)	
Step 1[a]	Land	.537	.235	5.201	1	.023	1.711
	Share_Cashew	-1.336	1.825	.536	1	.464	.263
	Constant	-.466	.843	.306	1	.580	.627

a. Variable(s) entered on step 1: Land, Share_Cashew.

2. Radio

Omnibus Tests of Model Coefficients

	Chi-square	df	Sig.
Step 1	Step	2.933	2	.231
	Block	2.933	2	.231
	Model	2.933	2	.231

3. TV

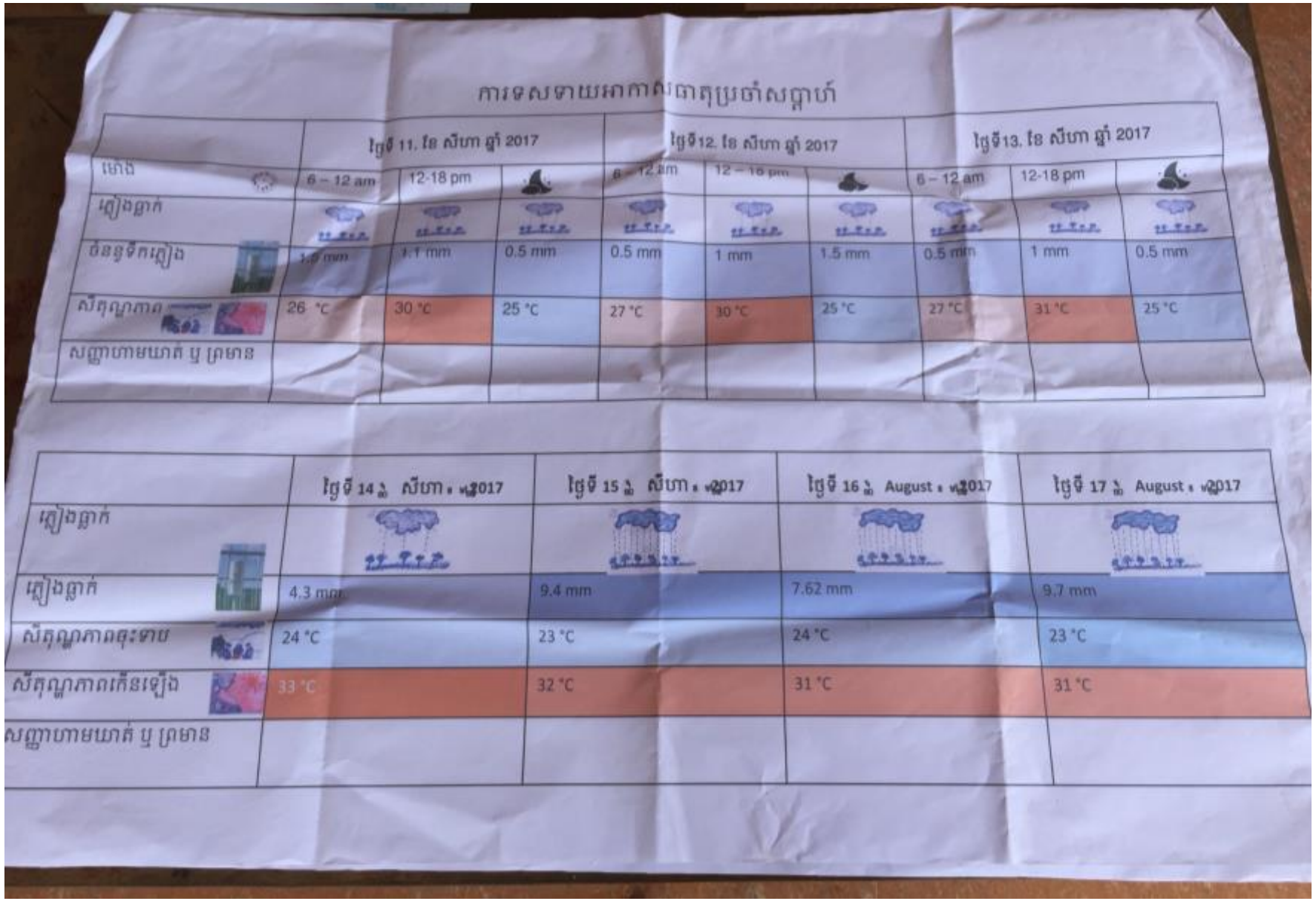
4.

Omnibus Tests of Model Coefficients

	Chi-square	df	Sig.
Step 1	Step	4.911	2	.086
	Block	4.911	2	.086
	Model	4.911	2	.086

Annex V – Forecast Products

One week format with Rainfall and Temperature



3-Month Format with Rainfall and Temperature



Mobile phone based 3-day format



Weather forecast for Pom: 09. Aug: Light rain (0-5mm), 25-28 °C; 10. Aug: …..

One month format with rainfall and temperature and verbal description

Forecast for Month 09 – Pom Village

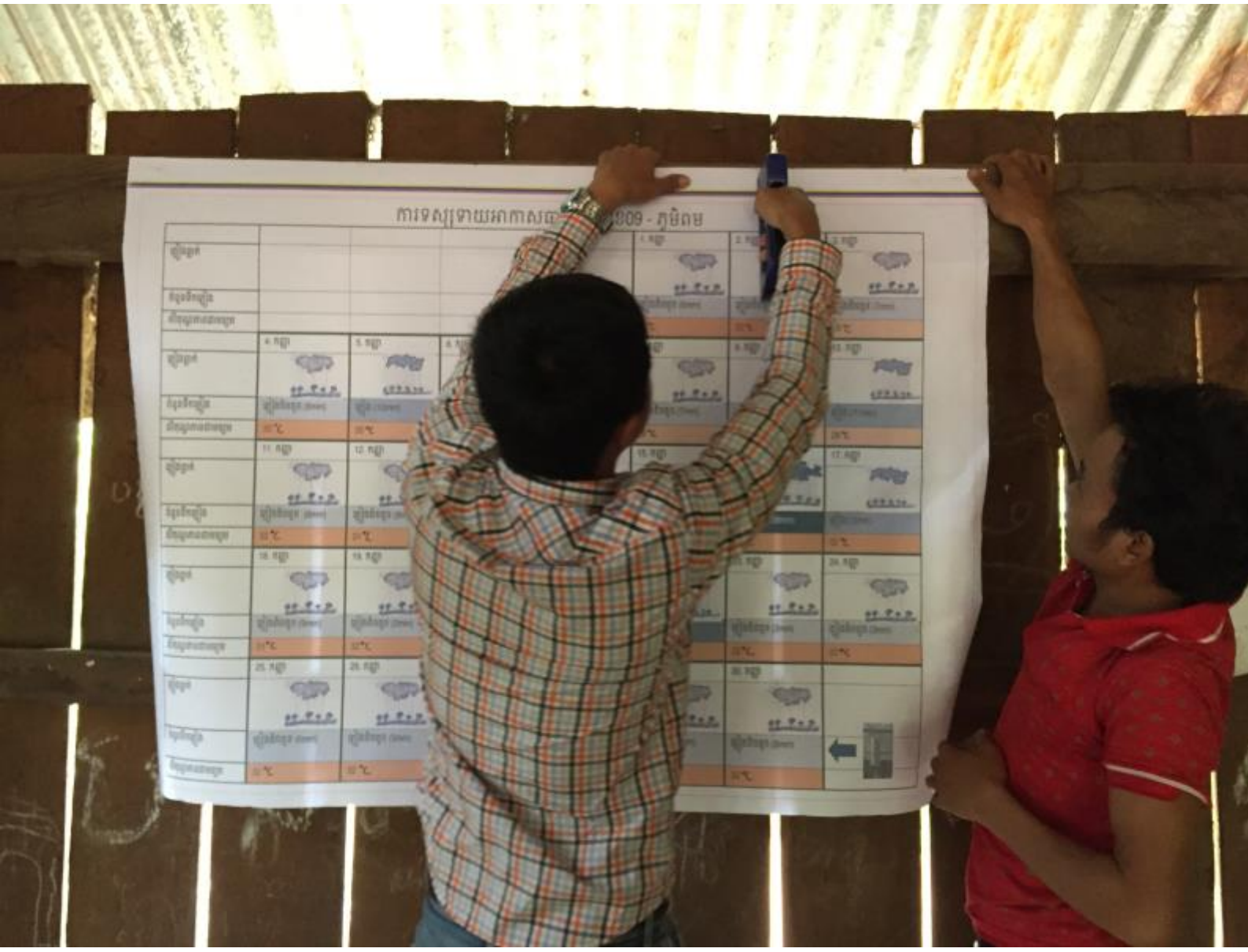
Weather								
Rainfall								
Temperature						30 °c	30 °c	29 °c
	4.	5.	6.	7.	8.	9.	10.	
	(54mm)	(6mm)	(6mm)	(7mm)	(6mm)	(9mm)	(7mm)	
	29 °c	29 °c	29 °c	30 °c	30 °c	30 °c	30 °c	
	11.	12.	13.	14.	15.	16.	17.	
	(8mm)	(7mm)	(0mm)	(5mm)	(8mm)	(15mm)	(11mm)	
	30 °c	30 °c	31 °c	30 °c	31 °c	31 °c	30 °c	
	18.	19.	20.	21.	22.	23.	24.	
	(1mm)	(5mm)	(6mm)	(9mm)	(17mm)	(13mm)	(16mm)	
	31 °c	31 °c	31 °c	32 °c	30 °c	30 °c	31 °c	
	25.	26.	27.	28.	29.	30.		
	(8mm)	(7mm)	(6mm)	(3mm)	(9mm)	(12mm)		
	32 °c	32 °c	32 °c	32 °c	33 °c	32 °c		

Annex VI – Aggregated Scores from the FGDs discussions

	Men	Women	Young	Old	IP	None-IP
	Average	Average	Average	Average	Average	Average
Radio	4.3	4.5	4.7	4.1	4.7	4.1
NGO	4.4	4.6	4.5	4.6	4.6	4.4
TV	3.6	4.2	4.6	3.4	3.7	4.3
Signpost	2.4	2.7	2.6	2.3	2.8	2.3
Loudspeaker	3.6	4.0	3.7	3.9	3.8	3.8
Mobile phone	3.3	2.8	3.8	2.4	2.8	3.3
AD	4.6	4.7	4.4	4.7	4.8	4.2

	Young Women	Old Women	Young Men	Old Men	IP Women	None-IP Women	IP Men	None-IP Men
	Average	Average	Average	Average	Average	Average	Average	Average
Radio	4.5	4.3	5.0	3.8	4.7	4.4	4.7	3.6
NGO	4.4	4.8	4.5	4.3	4.7	4.5	4.5	4.2
TV	4.8	3.7	4.3	3.0	3.7	4.8	3.7	3.3
Signpost	3.0	2.0	2.1	2.7	3.1	2.2	2.4	2.5
Loudspeaker	3.7	4.3	3.8	3.4	4.0	4.1	3.7	3.3
Mobile phone	3.9	1.8	3.8	3.0	2.5	3.1	3.2	3.7
AD	4.2	4.8	4.8	4.5	4.8	4.2	4.8	4.2

Annex VII – Training Manual for Forecast Design



Training Manual – Creating Forecast Products for Ratanakiri

Patrick Smytzek, M.Sc Fellow
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Part I – Accessing Weather Information

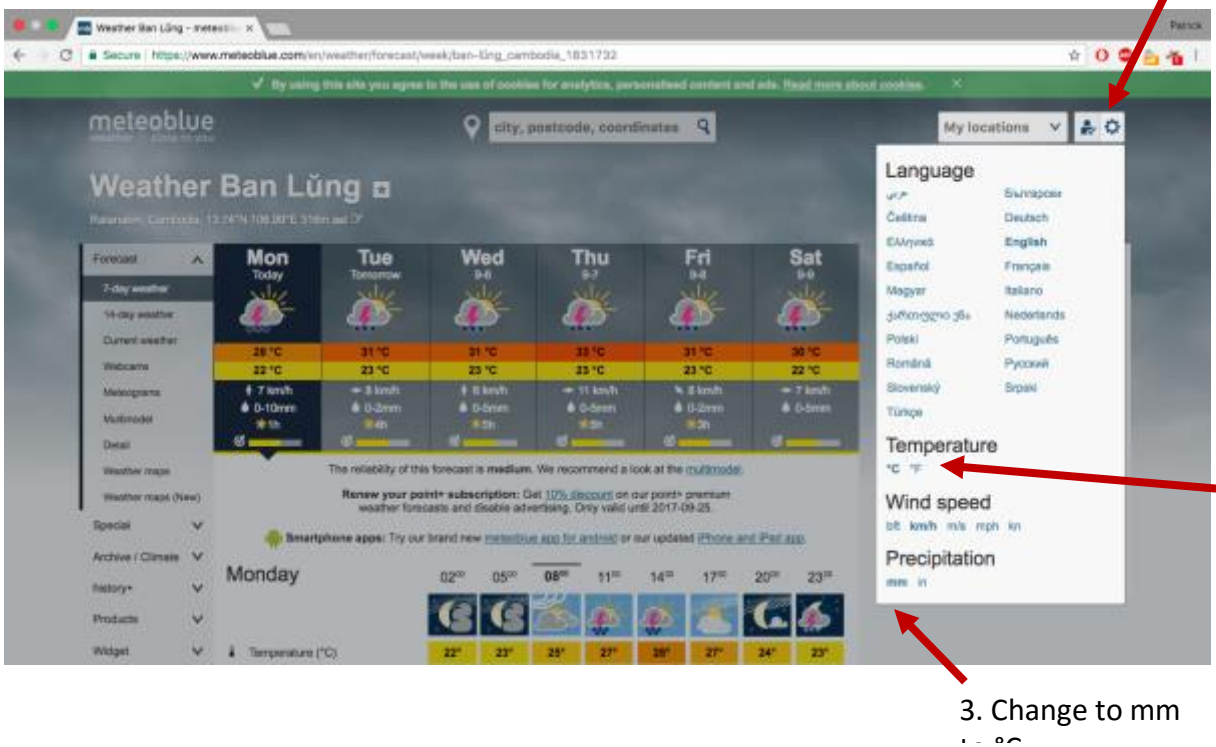
1. Meteoblue has forecasts for specific locations in Ratanakiri for up to 14 days available.

   You can access it here:

   http://www.meteoblue.com

   Make sure temperatures and precipitation are displayed in °C and mm and not in °F and In.

   If you want to change it. Follow the following steps.



2. There are different ways to find the location you look for.

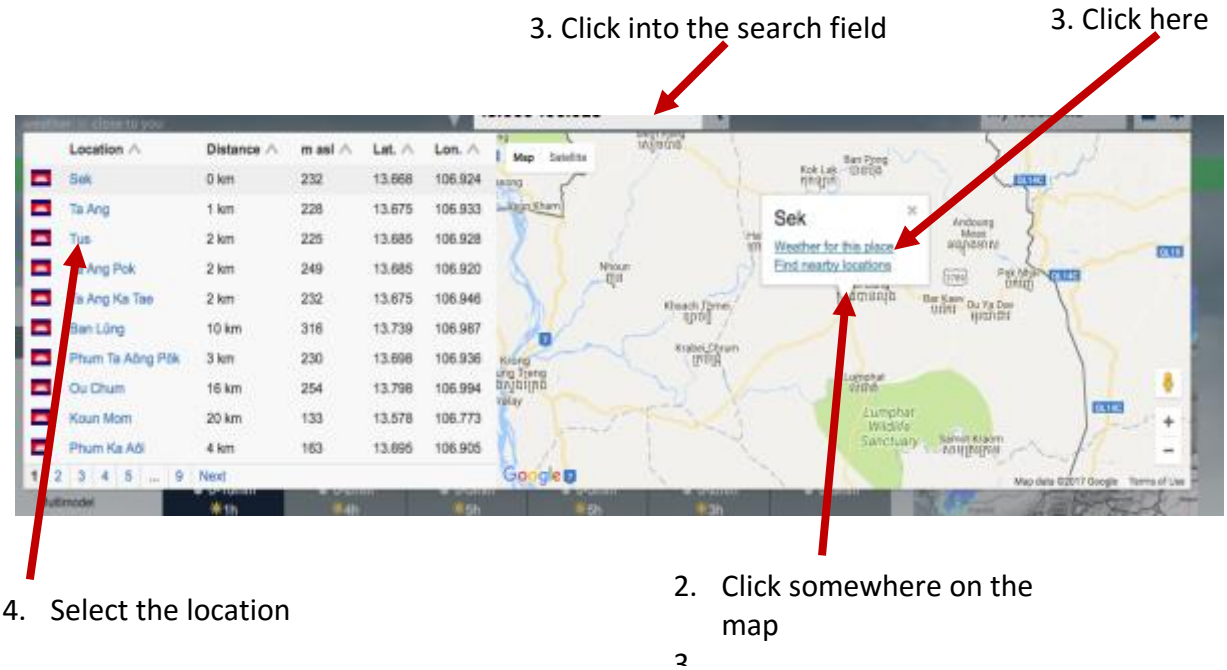
   a) By name or coordinates:

   - Type the name or the coordinates into the search field (ex. Banlung, 13.680° 106.843° for Teurn).

b) On the map

1. Just click in to the Search field
2. Click on the location of the map
3. Then click on “Find nearby locations”
4. A list will be displayed on the left side. Select the desired location

Ex. Tus



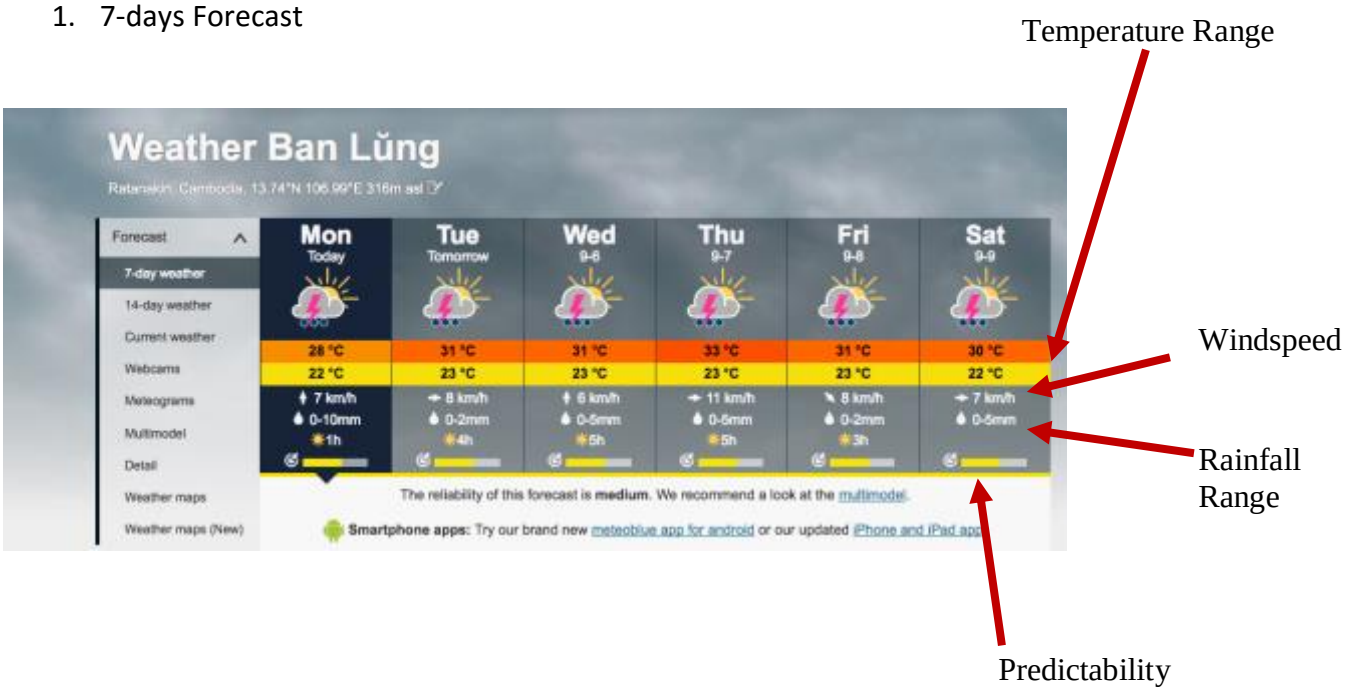
3. Meteoblue offers two different forecasts

a) A 7-days forecast
b) A 14-days outlook

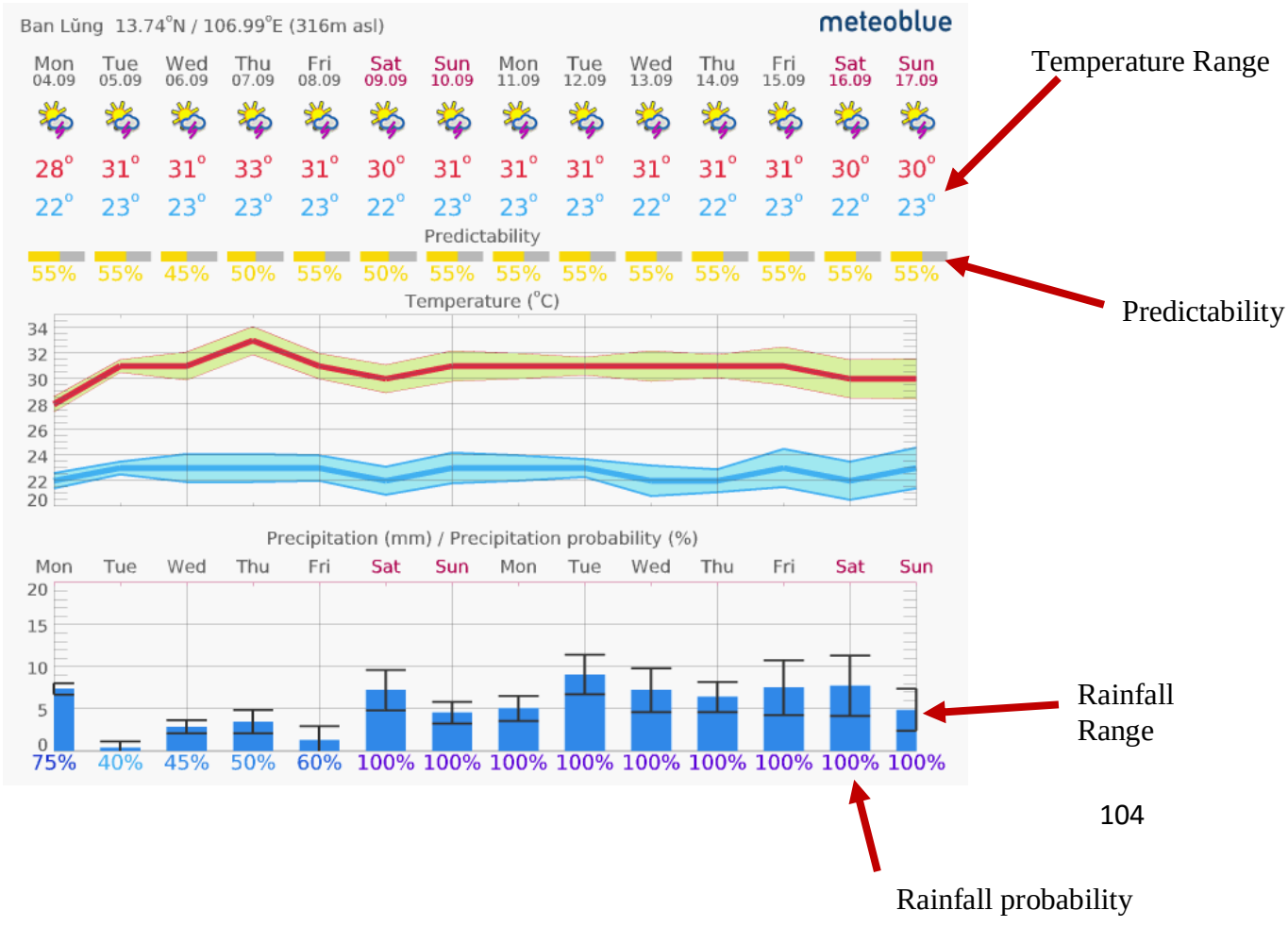


Part II – Interpreting weather information

1. 7-days Forecast



2. 14-days forecast



Part 3 – Developing Forecasts Products

1. Who are the extreme Users?

    - Not literate
    - No formal education
    - Not able to speak Khmer
    - No access to communication Technology

2. Ways to present information:

Visual Forecast	**Audio Forecasts**
Written descriptions	Verbal descriptions
Symbols, drawings	Numbers
Numbers	Sounds
Colors	

3. A simple forecast product

Date	**06 September 2017**
Picture	
Rainfall range	Light rain (0 -5 mm)
Temperature range	23 – 31 °C

Picture

Verbal description, Number, Colors

Numbers, Colors

- Color Scales

a) Rainfall

Rainfall Range	0-1 mm	2-10 mm	11-20 mm	21- 30mm	>30mm
Color					

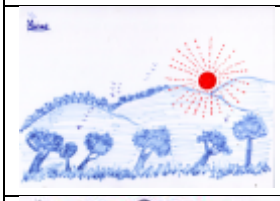
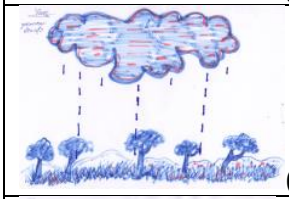
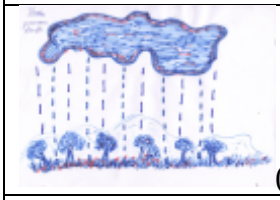
b) Temperature (use max. Temperature)

Temperature	15 – 19 °C	21 - 24 °C	25 – 29 °C	30 – 34 °C	>=35 °C
Color					

- Verbal descriptions

Description	Rainfall range
Light rain	2 – 9 mm
Rain	10 – 30 mm
Heavy rain	>=30 mm

- Pictures

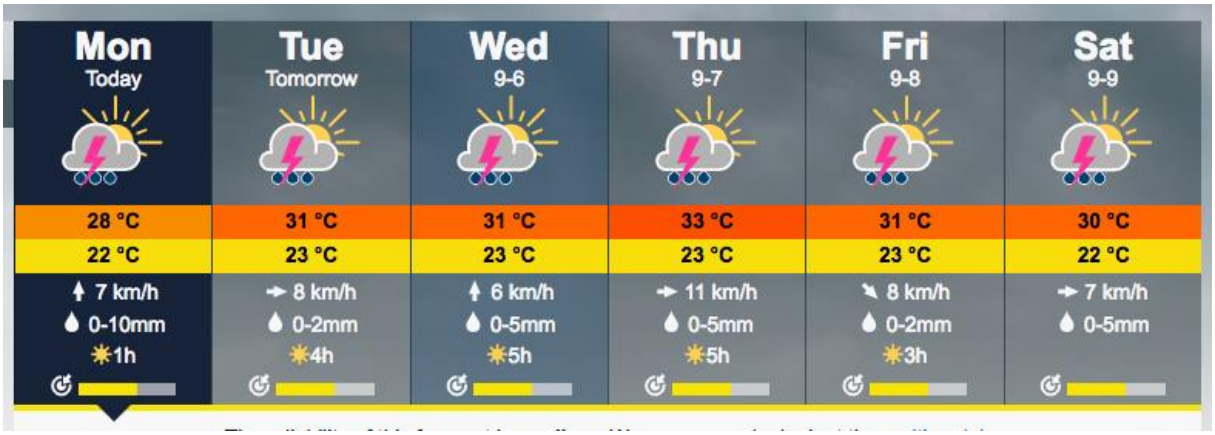
Picture	Rainfall range
 (sunny.png)	0 – 10 mm
 (light rain.png)	2 – 10 mm
 (rain.png)	11 – 30 mm
 (Heavy rain.png)	>30 mm

Part 4 – Evaluating forecasts

1. Take the forecast and check it against real data from the weather tool / rain gauges.
2. Do separately for rainfall and temperature

Ex.:

This is the forecast from Meteoblue.com



This is the recorder data for the same time and same location:

Day	**Min. Temp.**	**Max. Temp.**	**Rainfall**
Mon	22 °C	28 °C	7 mm
Tue	22 °C	31 °C	1 mm
Wed	23 °C	31 °C	7 mm
Thu	20 °C	32 °C	3 mm
Fri	22 °C	32 °C	10 mm
Sat	23 °C	29 °C	4 mm

It is suggested to consider a deviation of **+/- 1 °C** and **+/- 1 mm** still as accurate.

How many days was the forecast accurate?

For rainfall: 4 days

For Temperature: 5 days

How many percent of the days was the forecast accurate?

(Accurate days / Total Days) * 100

For rainfall: (4/6)*100= 66,67%
For temperature: (5/6)*100= 83,32%

Abstract

Agro-climate information services (ACIS) have the potential to facilitate adaptation among farmers, if they are actionable. An actionable ACIS provides useful and timely information, is accessible and understandable. This study assessed the potential for ACIS in the context of smallholder farming communities in Ratanakiri. PRAs, FGDs and interviews were combined to analyze the current situation, then different design options were developed and tested participatory. The cropping systems in Ratanakiri are highly dependent on seasonal rainfall patterns. The Perception of seasonal climate conditions vary among the population and are related to the experience of specific impacts. Currently, most farmers do not use climate information systematically in their decision processes. Barriers are the access, availability and the capacity to understand climate information. The ability to carry out desired actions is constrained by access to labor, land, technology and financial capital. Future climate change is likely to have adverse impacts on smallholder agricultural production in the area. The results suggest, that end-users have different capacities to access, understand and act on climate information. Socio-economic factors like gender, age and wealth influence these capacities. The design of agro-climate advisories requires a conscious balancing of trade-offs. Future research is needed to identify synergies that could arise from integrating ACIS with a wider system of extension services.

Key words

Agro-Climate Information Services; Participation; End-user groups; Ratanakiri; Forecast Design; Communication

Correct Citation: Smytzek, P. A. (2017). Participatory Development of Agro-Climate Advisories in Cambodia. M.Sc. Thesis (Sustainable Development in Agriculture). Montpellier: SupAgro.

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