Assessing water tenure security in highland watersheds: A case study from northern Thailand[1]

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Abstract

Water is a major and vital resource for household consumption and agriculture in highland watershed areas of northern Thailand. Concurrently, water is also used by mid- and downstream communities. Water scarcity and high demand during the dry season has triggered controversies over water use among relevant stakeholders. In general, water is perceived as a common-pool resource which can be accessed freely within a given geographical area. In fact, private, communal, state and open access rights are interacting in both complementary and conflicting ways. This study aims to analyze the complexity of water rights and the correlation of water and land rights, as well as to assess water security and livelihoods of the highlanders in this watershed. The watershed is characterized by an increased competition between upstream and downstream communities for irrigation water, while household/drinking water is still considered relatively secure.

Given the complexity of water resource tenure and management in Mae Sa Watershed and the importance of irrigation water, our study approached this issue in the form of "Water Security". A composite Water Security Index (WSI) was developed along three dimensions, namely (1) diversity of available water sources, (2) access to those sources expressed in percentage of irrigated land and (3) risks of conflicts and water scarcity. The assessment based on primary data from a representative survey of 240 farm households in eight villages conducted in 2004/2005 showed that the water security of the upstream communities was significantly lower than that of the downstream communities in all respects. Within the communities, the farm households were subdivided into two groups on the basis of the water security index. The assessment of farmers' livelihoods under different contexts of water security revealed that the group of farmers with high water security generated higher income

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than that with low water security. In addition, members of the group with high water security tended to hold higher social positions than those in the group with low water security, due to the positive influence of social status on water security. The risk assessment disclosed that the group with low water security encountered higher environmental risks than the group with high water security, due to total dependency on rainwater and the related high risk of drought situations. Due to intensive dependency on external production factors, the groups with high water security in upstream communities faced much higher risks than the groups with low water security. Another result of the study was that water rights reflecting water security were found to be positively correlated with secure land rights.

Our results provide evidence against the general perceptions among lowland people and policy-makers that upstream communities enjoy an abundance of water resources and have full access to water as compared to the downstream communities. Another stereotype is that upstream communities are the culprits of water scarcity and other negative externalities felt by downstream populations. Our study suggests that these perceptions need to be revised and that related policy planning should incorporate water security aspects.

Keywords: Water tenure security, livelihood assessment, highland watersheds, Thailand

1 Introduction

In Thailand, the perception of water as an open access resource is widespread (Wuttisorn, 2002). The existence of diverse forms of control, ownership and use rights of water resources is widely ignored by policy-makers. The presumed absence of clear institutions at the communal level is often used as an argument by governments for their enhanced control of the management of water resources. It is also widely believed that upland people – mostly belonging to ethnic minority groups – withdraw the largest share of the water resources at the expense of downstream communities. In fact, the intensity of water used for agriculture in many watersheds of northern Thailand has increased dramatically in both upstream and downstream communities. Among other factors, this is primarily a consequence of increasing land scarcity and the need for intensification of agricultural production on ever smaller plots. Cash crops such as fruits, flowers and vegetables, consuming a great amount of water as compared to upland food crops, have spread rapidly since the late 1980s. Whereas traditionally irrigation was only used to supplement rainfed agriculture in the highlands during the rainy season, today irrigation water is mainly applied during the dry season from February to May when water scarcity is most accentuated.

As a consequence, water conflicts between upstream and downstream water users in many watersheds of northern Thailand have become a common phenomenon and an expression of increasing water scarcity (Charoenmuang, 1994; Becu et al., 2006; Neef et al., in press). The rising water demand of non-agricultural sectors, such as tourism and processing industries, further aggravate water shortages. This paper aims at analyzing the complexity of water resource management as well as assessing highlanders' livelihoods under the context of water security.

2 Study area and methodology

The study was carried out in Mae Sa watershed in Chiang Mai province. The watershed covers an area of 142.2 km^2 and extends from 20 to 45 km northwest of Chiang Mai, in Chiang Mai province, Mae Rim district. The watershed is intensively used for market-oriented agriculture, mainly fruit, flower and vegetable production, and is also a favorite tourist destination for day trips from Chiang Mai. Major parts of the watershed are included in the Doi Suthep Pui National Park. It covers the three sub-districts Pong Yang, Mae Ram and Mae Sa. The main stream, the Mae Sa, has a length of 24 km, with about 20 creeks as tributaries. The Mae Sa feeds into the Ping river, one of the major tributaries of the Chao Praya river. The watershed is an upland area with mountainous terrain and altitudes ranging from 300 to 1400 m above see level. Precipitation differs in the watershed among locations and years; the average rainfall is at 1,160 mm, with about 85 percent concentrated in the rainy season. The population is composed by northern Thai (*khon muang*) and the Hmong ethnic minority group.

Four northern Thai and four Hmong communities in the upper part of the watershed (Pong Yang sub-district) were selected for this study (Figure 1). The upstream communities (Mae Sa Mai, Pha Nok Kok, Buak Chan, Buak Toey-Pang Lung and Pong Krai) are located either within the Doi Suthep-Pui National Park or in protected watershed areas. As a consequence, the agricultural land in these villages is – with few exceptions – owned without legal title deed. The downstream communities (Muang Kham and Pong Yaeng Nai), inhabited by local Thai, are located outside the boundaries of the national park and other protected areas. Land tenure is documented with legal title deed. The characteristics of the communities are depicted in Table 1. In each community, 30 heads of farm households were interviewed with standardized questionnaires from March 2004 to March 2005. In all villages, open and semi-structured interviews with key persons (e.g., village headmen, government officials, heads of water management committees and women groups) were also conducted from 2002-2004.

Location of water sources was determined by a mobile Global Position System (GPS) and integrated into a Geographic Information System (GIS).

Figure 1. Study area Mae Sa watershed

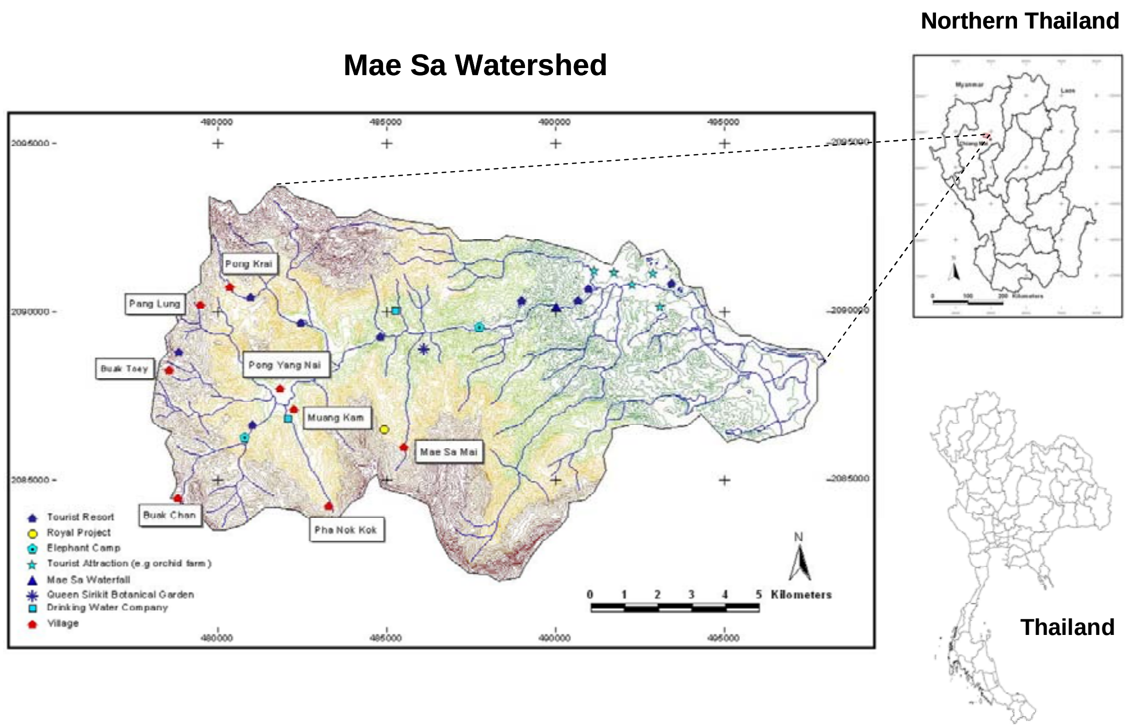

Table 1. Selected characteristics of the study villages

Village	Ethnic group	Major crops	Farm size (ha)	Household members
Upstream				
Buak Toey/ Pang Lung	Hmong/ Thai	Chrysanthemum (27%), rose (23%), litchi (20%)	1.22	7.6 3.8
Buak Chan	Hmong	Gerbera (48%), rose (10%)	1.50	8.9
Mae Sa Mai	Hmong	Litchi (87%), vegetables (20%)	2.71	9.7
Pha Nok Kok	Hmong	Litchi (30%), gerbera (20%), sayote (20%), chrysanthemum (13%)	1.87	6.3
Pong Krai	Thai	Chrysanthemum (67%), rose (17%)	0.81	4.2
Downstream				
Muang Kham	Thai	Chrysanthemum (50%), sweet pepper (33%)	0.55	4.4
Pong Yang Nai	Thai	Sayote (63%), chrysanthemum (20%)	0.51	3.6

Source: Own survey, 2004/2005

3 Water resource management in Mae Sa watershed

Water management in the villages of the Mae Sa watershed can be best described by the concept of legal and institutional pluralism. It refers to the coexistence and interaction of different legal orders in the same socio-political space (Griffiths 1986, Meinzen-Dick and Pradhan, 2002). According to Meinzen-Dick and Bruns (2000) and Ganjanapan (2003), this concept can be applied in particular to water rights and watersheds where different socio-cultural systems interfere with each other and a large heterogeneity of stakeholders exists. The often perceived concept of water rights being under an unregulated common-property system or a de facto open-access regime does not capture the reality of water rights and institutions for northern Thailand. The use rights and the practice of water utilization are rather bound into a complex governance system that reflects the socio-cultural background and local power structures. Hence, the property relations of water in the villages are not as simple as they appear; instead they are influenced by dynamic social, economic, and institutional factors. Over the years, the villagers have developed water conveyance systems for irrigation and domestic water to deal with increasing water demands. Every village has developed its own systems of water management depending on geographical, technical, social, cultural and economic factors. Both upstream and downstream farmers mainly use gravity irrigation with simple irrigation devices, such as pipes transferring water from streams or open irrigation channels. Small reservoirs, ponds and tanks serve as main storage systems. These structures make farmers strongly dependent on surface water sources and hence on the climatic and topographical conditions. Pumps and wells that would decrease this dependency are exceptions and are limited to few outside investors and more affluent farmers.

Different types of management patterns (individual, group, communal and a combination of them) can usually be found in the villages (Table 2). In individual water management schemes, a villager gets his or her own water from a stream through pipes or other devices without having any agreement with others about how much water can be withdrawn. This arrangement is mainly observed for irrigation water and more frequent in Thai villages. In Hmong communities, water management is usually organized on a group basis with local elites (usually the descendants of the founding families of the village) having a stronger voice than ordinary villagers. Conflicts are either regulated at the user group or the village level. Problems of water management that cannot be solved by the heads of water user groups or by water committees would be brought to the village headman and the village committee in both

Thai and Hmong communities. In Hmong villages customary institutions also play important roles in the determination of water allocation and in conflict mediation, such as the council of elders and the leaders of the different clans. In Mae Sa Mai, for example, the shaman and leader of the founding clan of the village coordinates the water use, mediates in disputes and performs a religious ceremony at the beginning of the irrigation season to honor the water spirit and to ensure permanent water flow (Neef et al., 2004).

Table 2. Water management systems in upstream and downstream communities

	Water source	Management scheme
Consumption		
Upstream communities	Communal water storage, creeks	Community management + fee (no-fee), private management
Downstream communities	Groundwater, bottled water, creeks, communal water storage	Private management, community management + fee (no-fee)
Irrigation		
Upstream communities	Creeks, communal and group ponds, private ponds	Community management, water user groups, shared among relatives
Downstream communities	Creeks, private ponds, groundwater, *muang-fai* system	Private management, shared among relatives, *muang-fai* system

Source: Own survey, 2004/2005

While the allocation of irrigation water tends to favor the long-established families, the politically powerful villagers and the more affluent farmers, access to domestic water is relatively equitable. Domestic water supply in the villages of Mae Sa watershed is mostly organized on a communal basis. Often the villages have one or more principal tanks to which all households are connected. Only in some villages water fees are collected either on a monthly or per connection basis (e.g. in the Thai village Pong Yang Nai) or per unit of water measured with water meters like in the Hmong village Buak Chuan. The case of Buak Toey, another Hmong community, shows that water fees are based on the costs of making the water available (installation, electricity), but not the real value of water; only those households which draw water from a system with electric pumps have to pay a fee, whereas households connected to a gravity supply system can get their water free of charge.

In sum, water management in the villages of Mae Sa watershed is a complex issue involving various institutions and different levels of management, from the individual and family to the group and village level. While collective action arrangements are effective and commonly accepted mechanisms for water allocation, local power structures or unfavorable topographical conditions can also lead to inequitable and non-sustainable water management.

4 Water security in upstream and downstream communities and implications for farmers' livelihoods

4.1 Development of a Water Security Index (WSI)

To assess the water security status of upstream and downstream communities and individual farmers, a composite Water Security Index was developed. It encompassed three dimensions of water security, namely (1) the diversity of available water sources, (2) access to those sources expressed in percentage of irrigated land, and (3) the risks of water conflicts and water scarcity.

(1) Diversity of available water sources

The first dimension of water security refers to the potential of farmers to diversify their water supply by having a variety of water sources at their disposal. Some farmers may have several choices of how to irrigate their fields, e.g., by surface water from creeks or ponds and by groundwater which reduces their dependency on one single water source and thus enhances their water security status. Other farmers might depend on just one source because of the location of their fields or their low social or economic status.

(2) Access to water sources expressed in percentage of irrigated land

This second dimension refers to the possibility to actually access the water sources that are available. It is an expression of both the physical and financial means to convey water to the farmland and the social capital to get a share of the available water resources. This dimension is expressed by the share of irrigated land in the total agricultural area of a farm or a community.

(3) Risks of water conflicts and water scarcity

The third dimension relates to the multiple risks that are associated with irrigated farming. Farmers can have diverse water sources at their disposal (dimension 1) and might be able to get physical access to these sources (dimension 2). However, if access to the resource is contested by other stakeholders, if upstream users claim a major share of the water or if the sources fall temporarily dry, water security can be seriously jeopardized, which is expressed by dimension 3.

4.2 Assessment of water security in the study villages

The assessment of water security in the eight study villages showed that upstream communities' water security was lower on average than in the downstream communities. This is mainly a result of a lower percentage of irrigated land and a higher risk of conflicts and water shortages in the upstream communities (Table 3). The results for the diversity of water sources, on the other hand, are mixed. Here, both the highest and the lowest value can be found in the two downstream villages respectively. In Muang Kham farmers enjoy the highest diversity of water sources, ranging from surface water (Mae Sa river and several tributaries, various springs) to groundwater which is an important source for the irrigation of sweet pepper in this village. In Pong Yang Nai farmers rely mostly on a single source of water. Diversity of water sources in the three upstream Hmong communities Mae Sa Mai, Pha Nok Kok and Buak Chan is relatively high. On the other hand, these three Hmong communities have the lowest percentage of irrigated land among the upstream communities and all study villages, followed by the mixed Hmong-Thai community Buak Toey-Pang Lung, while in the Thai village Pong Krai nearly all agricultural land is irrigated. The risk of water conflicts and water scarcity is most accentuated in Mae Sa Mai which is due to a relatively high water demand of litchi trees, the main production system in this Hmong village, and resource conflicts with an adjacent Botanic Garden.

Table 3. Water security in the study villages

Study villages	Index for diversity of water sources	Index for access to water sources	Index for risk of water scarcity	Composite Water Security Index (WSI)
Upstream villages	0.222	0.802	0.784	1.846
Buak Toey-Pang Lung	0.178	0.870	0.888	1.937
Buak Chan	0.269	0.719	0.760	1.748
Mae Sa Mai	0.287	0.775	0.489	1.551
Pha Nok Kok	0.252	0.664	0.899	1.816
Pong Krai	0.126	0.982	0.897	2.004
Downstream villages	0.229	0.928	0.821	2.010
Muang Kham	0.358	1.000	0.820	2.178
Pong Yang Nai	0.086	0.853	0.823	1.761

Source: Own survey, 2004/2005

In conclusion, the assessment shows that in all three dimensions upstream water security is lower than downstream water security.

4.3 Land tenure security and its correlation with water security

Large parts of the Mae Sa watershed are under a protected area status which affects the tenure security of most villagers, particularly in the upstream villages. The village territories of Mae Sa Mai and Pha Nok Kok are located in the Doi Suthep-Pui National Park where all agricultural activities are considered illegal and titled land does not exist. The other upstream villages (Buak Chan, Buak Toey-Pang Lung, Pong Krai) are in forest reserve areas which also poses severe restrictions on agricultural production and registration of agricultural land.

Table 4. Types of access to agricultural land in the study villages

Village	Access to agricultural land (% of total)					
	Forest clearance	Purchase	Inheritance	Rent	Free lease	No data
Upstream village						
Buak Toey-Pang Lung	63.29	5.01	15.90	-	9.04	6.75
Buak Chan	31.33	8.43	47.68	7.40	4.13	1.03
Mae Sa Mai	53.98	12.39	32.65	-	0.98	-
Pha Nok Kok	12.19	3.14	64.72	0.57	18.18	1.21
Pong Krai	25.7	6.71	49.26	8.51	9.82	-
Downstream village						
Muang Kham	12.62	20.63	45.15	4.37	15.53	1.7
Pong Yang Nai	23.35	4.93	42.02	11.15	10.77	7.78

Source: Own survey, 2004/2005

With the exception of Buak Toey-Pang Lung and Mae Sa Mai, inheritance is the most important type of access to agricultural land in the study area, followed by forest clearance (Table 4). The restrictions on land titling and registration in the watershed area are reflected in a relatively weak land market; purchase of agricultural land plays only a minor role.

Perception of tenure security is strongly determined by ethnic origin and location of the village. Hmong villagers in Buak Chan, Pha Nok Kok and Mae Sa Mai felt least secure on their land, while most villagers in the Thai downstream communities Muang Kham and Pong Yang Nai perceived their tenure security status as good. Farmers in the Thai village Pong Krai, which is located in an upstream forest reserve, felt much more secure than their Hmong counterparts under similar institutional conditions, which reflects the widespread political and marginalization of the Hmong in mainstream Thai society.

Results from a correlation analysis showed that land tenure security and water tenure security are strongly correlated (Table 5).

Table 5. Results of correlation analysis of water tenure security (WS) and land tenure security (LS)

		WS	LS
WS	Pearson Correlation	1	.186*
	Sig. (Two-tailed)		.007
	N	211	211
LS	Pearson Correlation	.186*	1
	Sig. (Two-tailed)	.007	
	N	211	211

* means that correlation is significant at a 0.05 confidence level

This implies that the lack of water tenure security in upstream communities is further exacerbated by the fact that tenure security for agricultural land is also significantly lower than in the downstream communities.

4.4 Assessment of highlanders' livelihood in the context of water security

In order to assess the impact of the different water security status on highland people's livelihoods, we looked into five livelihood dimensions. Four of them (physical, economic, environmental and social) are in accordance with the Sustainable Livelihoods Framework (SLF) developed by DFID (cf. Carney 1998), while one of them (risk) has been adapted to the specific purpose of this study, replacing the "human dimension" of the SLF (Table 6). In the following the results are discussed along these five dimensions.

Table 6. Livelihood dimensions and variables considered in the assessment

Dimension	**Index: Variables**
Economic	Income (I): Total household income, farm income Income Diversity Index (IDI): Number of remunerative activities Gini Index (GI): Measure for income distribution
Social	Social Security Index (SSI): Land tenure security, social position, education, food security, employment, access to credit
Physical	Physical Index (PI): Access to infrastructure, physical capital accumulation
Environmental	Conservation Index (CI): Soil conservation activities Awareness Index (AI): Knowledge and action in resource management
Risk	Environmental Risk Index (ERI): Erosion, forest fires, incidence of pests, health problems from agrochemical use Agricultural Risk Index (ARI): Price, labor shortage, limitation of credit, information

4.4.1 *Economic Dimension*

The economic dimension includes three variables which are income, income distribution and income diversification.

Income: Upstream and downstream villages' average household income is not different in terms of income generated from the agricultural sector and total income. However, in both upstream and downstream communities the group with high water security generates more agricultural income and a higher total income than the group with low water security, significant at a 95% confidence level. This confirms that water resources in this area play a crucial role in determining farmers' income and livelihood (Table 7).

Table 7. Water security and livelihood sustainability of the communities

Sustainable Livelihood Dimensions	Studied Areas					
	Upstream villages			Downstream village		
	High Water Security Group	Low Water Security Group	Average	High Water Security Group	Low Water Security Group	Average
Economic Dimension						
Income from agricultural sector	111,836	63,707	89,206	100,939	40,068	87,750
Total income	138,664	87,025	114,383	120,736	70,822	109,921
GINI Index (agricultural sector)	0.529	0.507	0.533	0.441	0.523	0.489
GINI Index (total)	0.443	0.397	0.439	0.426	0.430	0.443
Income Diversity Index (IDI)	0.387	0.430	0.407	0.309	0.274	0.301
Social Dimension						
Social Security Index (SSI)	0.632	0.548	0.592	0.606	0.625	0.609
Physical Dimension						
Physical Index (PI)	0.627	0.460	0.549	0.788	0.623	0.752
Environmental Dimension						
Soil Conservation Index (SCI)	0.183	0.200	0.191	0.113	0.141	0.119
Awareness Index (AI)	0.463	0.390	0.429	0.333	0.350	0.337
Risk Dimension						
Environmental Risk Index (ERI)	0.341	0.361	0.35	0.241	0.243	0.241
Agriculture Risk Index (ARI)	0.42	0.408	0.414	0.33	0.317	0.327

Source: Field survey, 2004/2005

Income Distribution: Income distribution is calculated by the Gini Index (GI) which can have a value between 0 and 1. A higher GI (closer to 1) means a higher inequality of income distribution. Distribution of agricultural income is more unequal in upstream than in downstream communities, while total income distribution is similar for both areas. Agricultural income distribution in the upstream villages does not differ significantly between the high and low water security groups.

Income Diversity: Income diversity is characterized by the Income Diversity Index (IDI) – high IDI represents high income diversity. Upstream and downstream IDI differs with significance at 95% confident level. Higher upstream IDI is an expression of diversified cropping systems, livestock keeping and off-farm employment. In upstream areas, the income diversity within the group with high water security was lower than that of the low water security group, which means that high water security households show a tendency of specialization, e.g. in litchi production under monoculture. In contrast, members of the low water security group cope with water scarcity by adopting a multi-cropping strategy. Being members of a socially and economically marginalized ethnic minority group, their off-farm employment opportunities are limited. The situation is different in the downstream area, where all farmers belong to the Thai majority: income diversity of the group with high water security was higher than in the group with low water security. Members of the group with low water security sought additional income from the non-agricultural sector, whereas their peers with high water security adopted multi-cropping farming practices.

4.4.2 Social Dimension

The social dimension includes land tenure security, food security, education, social position, public participation, livelihood security, community dependency, credit access and return payment. These variables are considered by the Social Security (SSI) (0-1). High SSI represents higher social security.

The analysis reveals that upstream and downstream SSI is not much different. In the upstream area, SSI difference between the high and low water security group was confirmed with significance at a 95% confidence level. The group with high water security has a higher SSI than the one with low water security. Upstream farmers holding a high social position in the village usually enjoy high water security. In contrast, the social dimension of the low and high water security group in downstream communities does not differ significantly.

4.4.3 Physical Dimension

Access to public utilities, e.g. electricity, road and health care and possession of physical assets, such as irrigation devices and other agriculture equipment (pumps, spraying tanks, trucks) are important parameters for farmers' livelihood and are summarized under the Physical Index (PI). Not surprisingly, the downstream PI is higher than the upstream one, mainly due to the difficult terrain of the highland location that hampers access to infrastructure. The PI of the group with high water security is certainly higher than that of the group with low water security in both upstream and downstream areas, since physical assets are an important means to get access to irrigation water. The differences are significant at a 95% confidence level.

4.4.4 Environment Dimension:

The environment dimension comprises the Soil Conservation Index (SCI) and the Awareness Index (AI).

Soil Conservation Index (SCI): This index refers to various soil conservation practices, such as rotational farming, use of organic fertilizer, reduction of agrochemical use, use of bio-extracts, fallow, terracing, drainage in farm plot, alley cropping, contour farming, mulching and lime use. These variables are subsumed under the Soil Conservation Index (SCI). The average SCI of high and low water security households in upstream and downstream is similar. This means that water security differences do not have a significant impact on soil conservation. However, the average upstream SCI is much higher than the downstream SCI. This may be explained by the active campaigning by government agencies for soil conservation practices in upstream watershed areas, but also by traditional local conservation practices.

Environment Awareness Index (AI): This covers the awareness of the environmental services of natural resources and of the need of environmental protection. The highest AI was found among the group with high water security in upstream area, while their peer group in the downstream communities showed the lowest AI. Overall upstream AI is higher than downstream AI with significance at a 95% confidence level, which can be explained by a long tradition of forest conservation among highland communities and intensive government campaigning for watershed protection in these areas.

4.4.5 Risk Dimension

The risk dimension covers several parameters namely (1) environmental risks, such as natural disasters (e.g. forest fire and severe disease or pest outbreak), soil erosion, chemical use and health impact, and (2) agricultural risks, such as price and input supply fluctuations, labor and credit shortages, inadequate equipment, insufficient information or marketing barriers. These parameters are presented in the Environmental Risk Index (ERI) and Agricultural Risk Index (ARI).

Environmental Risk Index (ERI): The study reveals that upstream ERI is higher than downstream ERI with significance at a 95% confidence level, due to the more unfavorable highland location and agricultural land on steep slopes. The average ERI of households with low water security is slightly higher compared to the households with high water security both in the upstream and downstream areas, which reflects the higher dependence on rainwater in the group with low water security.

Agricultural Risk Index (ARI): Upstream ARI is higher than downstream with significance at a 95% confidence level due to a more diversified cropping system on downstream farms. Upstream crops are negatively affected by the Thai-Chinese Free Trade Agreement, while downstream crops, e.g. chrysanthemum and eggplant, do not compete with the Chinese market. Sweet pepper grown under contract farming is also less subject to market risks. The ARI of the group with high water security is higher than the ARI of the group of low water security both in upstream and downstream communities; farm households with high water security tend to grow high-value crops in response to market demand and rely on external factors, e.g. improved seeds and agrochemical, which recently have experienced drastic price increases due to rising energy prices. In addition, the vegetable market is subject to high price volatility.

In sum, the livelihood analysis shows that the degree of water tenure security is linked to physical and social capital accumulation and affects livelihoods of highlanders particularly in terms of income generation.

5 Conclusions and policy implications

Our results provide evidence that communities in highland watersheds of northern Thailand are fairly heterogeneous with regard to both water management practices and water security. Policy-makers should not underestimate the complexity of local water governance and should aim for legal frameworks that allow flexible adaptation of institutions in ways that do justice to the differences in resource access and social contexts. The general perception – prevalent among lowland people and policy-makers – that upstream communities enjoy an abundance of water resources and have full access to water as compared to the downstream communities needs to be reconsidered. In fact, the notorious lack of land tenure security in upstream areas due to their location in sensitive watershed zones and protected areas is further aggravated by a considerably lower water tenure security. The policy implication of our study is that policy planning needs to incorporate water security aspects. To meet both the demands of upstream and downstream water users, currently emerging institutions, such as river basin committees and watershed networks, must recognize the need for transparency, participation and impartiality. If certain groups need to reduce their water demand and/or invest their time in conserving water resources, they should be compensated in order to be able to sustain their livelihoods. Payment for Environmental Services (PES) schemes, that have proven successful in other locations, need to be put in place to provide incentives for water resource conservation and to ensure the adoption of water-saving agricultural practices and technologies.

On the methodological side, we believe that the Water Security Index can be a valuable tool for assessing water security of various stakeholder groups in different highland watersheds of Thailand and mountainous regions of other countries to determine the vulnerability of particular social groups and agroecological zones in terms of water scarcity and access to water resources.

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