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CHAPTER 8

DROUGHT RISK MANAGEMENT IN VIETNAM

Huy Nguyen and Rajib Shaw

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INTRODUCTION

Vietnam is located in the tropical monsoon area, one of five storm hubs of Pacific Asia, and is regularly faced with various disasters. Drought, a normal part of the climate for virtually all regions of Vietnam, is of particular concern, where an interruption of the country already limited water supplies for extended periods of time can produce devastating impacts. Historical records indicate that drought occurs almost everywhere in those places almost every year (Hieu, 2002). However, multiyear droughts are of great concern to water-resource managers, natural-resource managers, and policy makers (Nguyen, 2010b).

The severe drought of 1998 in the central highlands and 2004 on the south central coast of Vietnam demonstrated the continuing vulnerability of the region. This vulnerability became even more apparent during the period from 2000 to 2004, when some parts of the south experienced 3 or 4 consecutive years of drought. Drought conditions returned to large portions of the region in 2004, mainly Ninh Thuan province and again in 2005 in the whole central region. The 2004 drought caused significant impacts in agriculture and forestry and resulted in depleted reservoirs, increased groundwater pumping, interruptions of public water supplies, and reduced recreational opportunities and tourism revenues. Environmental and social

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impacts were significant, particularly the tremendous increase in forest and range fires, soil erosion, and effects on fish and wildlife populations (Shaw, Prabhakar, Nguyen, & Provash, 2007).

The National Strategy for Natural Disaster Prevention and Mitigation, approved by the Prime Minister in 2007, is a milestone in Vietnam's disaster prevention, response, and mitigation and sustainable development on the basis of traditional experience and achievements as well as the world's lessons in disaster control for increasingly sustainable development in the context of natural disasters. The National Strategy promulgates tasks, solutions, and plans for implementation; the 63 provinces and 12 ministries developed their strategic action plans based on these. However, considering that drought is the third-ranked disaster with respect to its impact on the socioeconomic conditions of Vietnam, not enough attention was paid to drought risk management. Different levels of government need to plan to mitigate the impacts of drought. Future policies and activities must include drought management as an integral part of disaster management in Vietnam; this will require an interagency approach that extends well beyond drought risk management.

The purpose of this chapter is to provide an overview and analysis of drought risk management issues in Vietnam. We will provide an overview of drought risk management, including the definition of drought and its patterns and trends, as well as discuss drought risk management in Vietnam. We will also use the Standardized Precipitation Index (SIP) approach and provide a case study analysis in Ninh Thuan province of the socioeconomic, institutional, and physical resilience with regard to drought risk management (Habiba, Shaw, & Takeuchi, 2011). We also provide measures for drought resilience at the local level in rural areas.

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DROUGHT DEFINITION AND RECOGNITION IN VIETNAM

Drought Definition

According to data from a drought research study at the national level (Hoc, 2002), drought events were identified based on the drought index, which uses hydro-meteorological data to indicate the meteorological drought. Since the drought index has been applied in Vietnam in recent years, the definitions of drought are based on the impacts of drought on water resource (hydrological drought) and agriculture (agricultural drought).

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Following these definitions, we can understand that the agricultural drought is effectively also just a concept, which reflects the perspective of an agricultural sector on water shortages. This concept links the lack of precipitation (or other sources of water supply, such as river flow and groundwater) to agricultural impacts. Crop water requirements depend on local weather conditions, soil and plant characteristics, and plant stage of growth. The extremity of an agricultural drought should therefore ideally be defined in terms of its impact on a specific plant on a specific soil in a specific area, which makes it a difficult task to accomplish. In more general terms, agricultural drought exists when root-zone soil moisture is insufficient to sustain crops between rainfall events. In this context, the status of soil water deficit in the top meter of a soil profile may be used as a drought measure. In practical terms, some of the indexes referred to above are used to monitor the developing deficits of water availability to crops. Hydrological (surface flow and groundwater) drought is understood as the impact that the lack of precipitation has on hydrological systems. In some cases, the impact on both rivers and aquifers are included in this category. In other cases, a ‘‘flow drought’’ is distinguished’’ from a ‘‘groundwater drought.’’ In both cases, a hydrological drought usually lags behind the deficient precipitation. It takes longer for precipitation deficiencies to manifest themselves through the river flow or through the groundwater level.

Drought Recognition Tool

Drought is a slow-onset hazard, and it is difficult to recognize when it begins and when it ends (Wilhite, 2000). In Vietnam, the start of a drought is defined as the time when total of rainfall in a year is less than 80% of the annual rainfall or when there is no rain or less than 1.0 mm of rain within a 14-day period .

The Vietnam Institute of Meteorology, Hydrology and Environment (IMHEN) provided some methods for drought recognition based on some complex drought indexes, one of which, and the most frequently applied, is the Palmer Drought Severity Index (PDSI) (Palmer, 1965). Other multi-variable indexes are, for example, the Surface Water Supply Index (SWSI) (Shafer & Dezman, 1982), the Standardized Precipitation Index (SPI) (McKee, Doesken, & Kleist, 1993), and the Crop Moisture Index (CMI) (Palmer, 1965). Those drought indexes need long-term climatic data records and staff, both of which are lacking in Vietnam. The solution is to provide some simple method for determining the occurrence of a drought. For example – drought period: rainfall less than 20 mm in a period of 20 days; drought week: rainfall less than 5 mm in a week; drought month: total rainfall less than 10 mm in a month (IMHEN, 2009).

OVERVIEW OF DROUGHT IN VIETNAM

Patterns and Trends of Drought

By identifying drought events, we can see the history of drought in Vietnam, as shown in Table 1 (Hieu, 2002; Hoc, 2002; Shaw et al., 2007; Tinh, 2006). The table shows that droughts occurred in all regions of Vietnam. In the mountainous area of the north and the Red River Delta, droughts occurred in the winter–spring season (from November to March) and the summer season (from April to July). There was no drought recorded in these two regions in the summer–autumn season (from July to October). Droughts were recorded at all other regions at all seasons of the year (Table 1 and Fig. 1).

Table 1. Drought Events in Vietnam from 1952 to 2005.

Region	Years of Drought		
	Winter–spring season	Summer season	Summer–autumn season
Mountainous area in the north	1988, 1990, 1991, 1993, 1994, 1996, 1998	1988, 1990, 1991, 1992, 1993, 1998	
Red River Delta	1960, 1961, 1963, 1964, 1986, 1987, 1988, 1991, 1992, 2004, 2005	1987, 1990, 1998	
North central region	1991, 1992, 1993, 1994, 1996	1982, 1983, 1984, 1988, 1992, 1993, 1995, 1998	1991, 1992, 1993, 1994, 1995, 1996, 1998, 2004
South central region	1977, 1978, 1983, 1984, 1993, 1998, 2002, 2004, 2005	1983, 1993, 1994, 1997, 1998, 2000, 2004, 2005	1952, 1969, 1970, 1971, 1977, 1978, 1983, 1982, 1984, 1985, 1993, 1998, 2000, 2001, 2002, 2004, 2005
Central highlands	1994, 1995, 1996, 1997, 1998	1997, 1998, 2001, 2002, 2004, 2005	1983, 1988, 1993, 1995, 1997, 1998
Southeast region	1987, 1988, 1990, 1992, 1994, 1997, 1998	1988, 1990, 1992, 1997, 1998	1988, 1990, 1992, 1998
Mekong River Delta	1989, 1992, 1993, 1998, 2004	1981, 1983, 1984, 1985, 1987, 1992, 1994, 1998, 2004	1981, 1982, 1988, 1992, 1997, 1998

Source: Hieu (2002), Hoc (2002), Shaw et al. (2007) and Tinh (2006).

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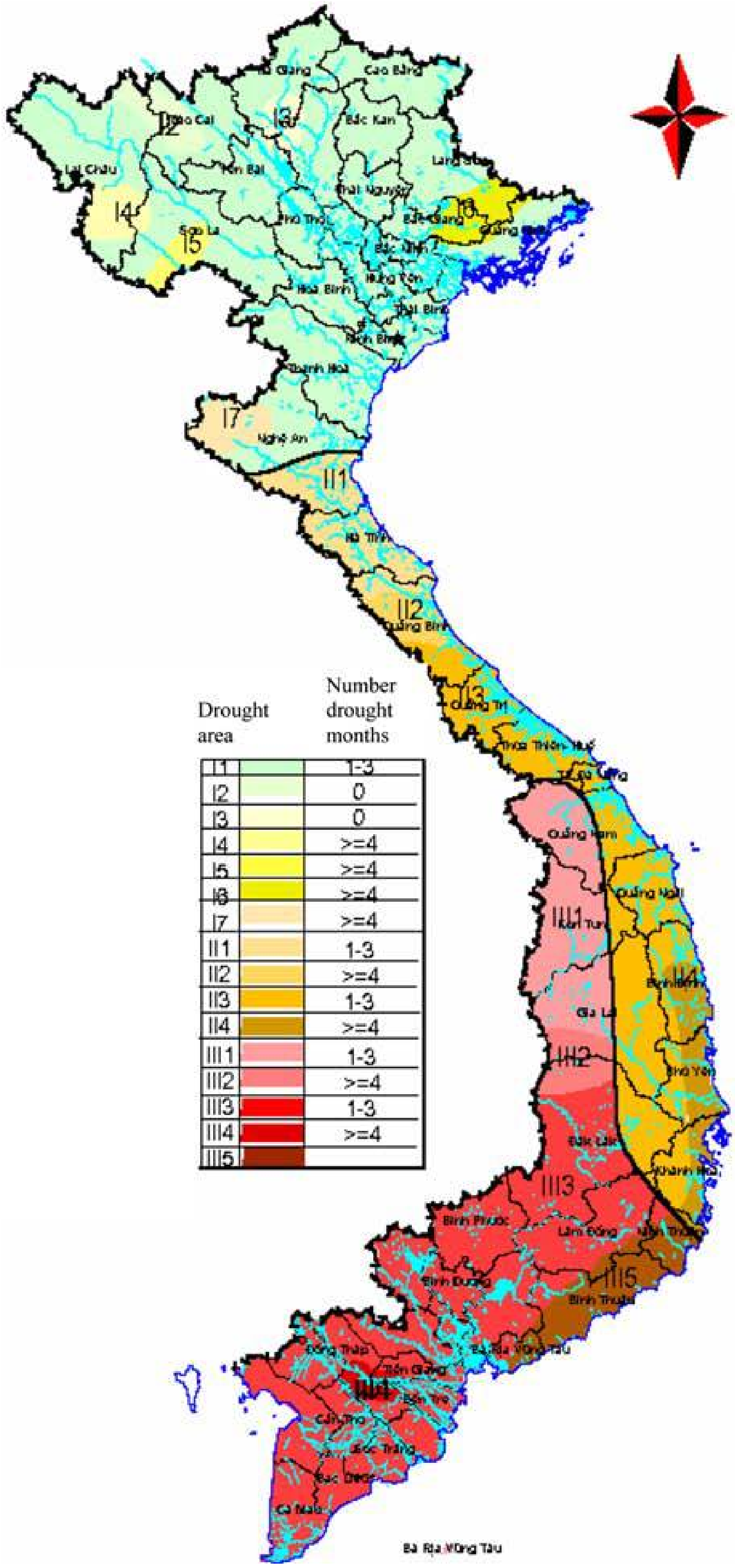

Fig. 1. Spatial Areas of Drought in Vietnam – Average Data from 1960 to 2005. *Source*: Nguyen (2010b).

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Drought Impacts in Vietnam

The history of drought events in Vietnam indicates that drought has occurred in the whole country. The most drought-prone regions are the south central and the central highlands. Observations have also indicated that the frequency of drought in Vietnam shows an increase in recent years. Statistical records of the national Hydro-meteorology Institute show that the consequent impacts of drought on the environmental and socioeconomic sectors of Vietnam in general are comparable to damages caused by floods and typhoons. A deficit of rainfall over a certain period in combination with high temperature and high potential evaporation may lead to huge deficiencies of the water supply over the region, which subsequently may turn into a large-scale drought, with impacts on the water-using sectors (e.g., losses in agricultural production, emerging of forest fires, and reservoir depletion) as well as on related sectors (e.g., causing famine, diseases, and conflicts). Since drought is a slow-onset disaster, the assessment of drought impacts on the socioeconomic sector is difficult. The available data on drought impacts at the national level is limited. Thus, this section focuses mainly on the impacts of drought on agriculture (Hoc, 2002).

The drought of 1976 in the northern and north central regions destroyed 370,000 ha of cereal, whereas the one in 1982 destroyed 180,000 ha of cereal in six provinces of the Mekong delta. Similarly, in 1983, a total of 291,000 ha of crops were lost in central and southern Vietnam. In the winter–spring of 1992–1993, rice production in the Mekong River Delta was reduced by 559,000 tons. In 1993, about 175,000 ha of the central region had experienced drought, in which 35,000 ha had completely dried, with a loss of 150,000 tons of crops. The 1994–1995 drought in Dak Lak province was considered to be one of the most serious droughts in 50 years. This drought has had a serious effect on the cash crops in this area, especially coffee trees, with an estimated loss of up to 20 million USD, and it has created a severe shortage of water. Another drought took place in 1995–1996 in the northern part of the country, which claimed 13,380 ha of northern middle-land and mountain and another 100,000 ha of Red River Delta (Hoc, 2002).

Widespread droughts in Vietnam in 1988 and 1998 were clearly related to El Niño, especially the one in 1997–1998. The effects were so strong that it produced severe drought and widespread water shortages all over the country. The rainfall was much lower in the winter–spring 1997–1998, especially the northwest, south central, central highlands, and southern regions of Vietnam. In the summer of 1998, rainfall was reduced by 10% to 50%. By late 1998, the rainfall continued to drop by 30% to 50%, and up to 90% in some localities

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(e.g., Son La), as compared with the average rainfall of many years before. In November, many localities in the vicinity of the Red River Delta were also having water shortages (Kim, Tinh, Cintia, & Dan, 2005).

According to statistics made from the Water Resources University, there were 11 crops in Vietnam that were seriously affected by drought from 1976 through 1998. These led to severe damage, such as loss of agricultural production (100,000 ha of rice, coffee, tea, and fruits destroyed), forest fires, thousands of water reservoirs dried, serious incursions of seawater into inland areas, and a lack of fresh water in many places, leading to tremendous economic loss. The drought event from December 1997 to June 1998 occurred in almost all parts of the country. During this event, the temperature rose very high (from 35°C to 42°C), the rainfall amounts were 40–250 mm, just 5% to 20% of the average rainfall in years past. These factors together with the low air humidity and dry, hot wind from the west made canals, lakes and water reservoirs run out of water. The humidity of flammable materials dropped under 15%. Therefore, flying ash from only a small fire could flame up and cause a forest fire. There were about 3.8 million people lacking freshwater in the whole country. General loss and damage in the whole country totaled more than 30 million USD (Hoc, 2002).

In the north of Vietnam, about 20% of the winter–spring rice area was affected by drought, approximately 2,000 ha of which were lost completely, the environment was exhausted, production of industrial plants and fruits trees were reduced, and diseases developed. About 300,000 people lacked drinking water. The government spent 2.5 million USD to mitigate the effects of drought.

In north central Vietnam, 62,000 ha experienced severe drought, accounting for 46% of planting area in the whole region, of which about 50% was completely lost. More than 800 medium- and small-scale water reservoirs were completely dried up, and 2.1 million people lacked fresh water.

In the south central coastal area, the drought in 1998 threatened all winter–spring, summer–autumn, and winter rice crops, with a total dried area of all three crops reaching 20.3% to 25.0% of planting area. Seawater invaded coastal inland areas from 10 to 15 km, causing serious salinization. The provinces in the region have always been threatened by drought for the past 10 years, and in 1998 there were 203,000 people who lacked fresh water.

In the central highlands, including the provinces of Gia Lai, Kon Tum, Dak Lak, Lam Dong with a winter–spring rice and winter rice area of 24,000 ha, 7,800 ha of which was lost because of the drought in 1998. Industrial plants, such as tea and coffee died. The total dried area of

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industrial plants and fruit trees reached 110,000 ha, with 20,000 ha of plants dead. About 800,000 people lacked fresh water. The drought caused huge economic losses and damage to livelihoods in the region.

In the Mekong River Delta, the Mekong River's water level at Tan Chau and Chau Doc is normally lower than 1.0 m above sea level. In 1998, the water level lowered to 0.30 to 0.40 m below sea level. Water with a salinity of 4% invaded inland areas to 45 km, making two thirds of Ca Mau peninsula's water salinized. The drought also seriously affected 275,000 ha of summer–autumn rice, with more than 32,000 ha of rice fully lost. The 1998 droughts produced huge economic losses in all parts of the country (Table 2).

In 1999, drought continued to strike many parts of the country. Droughts with hot and dry conditions can easily lead to forest fires. During the early months of 1998, there were 60 forest fires in Dong Nai and Dak Lac, which destroyed 1,200 and 316 ha of forests, respectively. From May to August of 1998, about 11,370 ha of forests burned.

Prolonged droughts can seriously affect society in large regions. The shortage of water affects not only agriculture but also other economic sectors and society as well. Ecological and economic impacts are always closely linked together with social impacts (Lien, 1999). Because of the limitation of statistical figures on all sectors affected by drought events since the 1980s in Vietnam, little information was obtained on the severe drought event related to the 1997–1998 El Niño episode, which was considered to be the strongest event in the 20th century. Most regions in Vietnam, especially those in the central and southern parts of the country, were significantly affected by severe drought, causing adverse impacts on livelihoods and the

Table 2. Economic Loss Caused by Drought in 1998.

Region	Total Area (ha)	Area Affected (ha)	Area Died (ha)			Cost (Billion VND)[a]
			Rice	Summer crop	Winter vegetables	
North central	739,804	107,880	6,612			21.8
Red River Delta	526,869	32,578				9
Central coastal provinces	628,999	122,139	3,922	74,613	469	68.0
Central highlands	127,403	147,646	33,464	7,421		22.3
Southeast		26,361		5,176	477	22.3
Mekong Delta		276,656	7,775	231	3,032	34.0

Source: Data from General Department of Hydro-meteorology.
[a]In 1998, 1 USD = 15.000 VND.

national economy. According to a drought assessment of the Ministry of Agriculture and Rural Development, in 1997–1998 about 3 million people were affected and the total losses in terms of agricultural production were estimated at about 400 million USD. In addition, diseases related to the lack of food, water salinization, and hot weather were observed. Some diseases became epidemics during the drought event; about 250,000 people were infected by dengue fever in Vietnam (Lien, 1998). There were no statistics on other sectors such as fishing and ecosystem losses, recreation and tourism, and so forth, but all of them were considerably affected (Lien, 1999). See Table 3.

The most recent drought in March and April 2002 occurred in the Cuu Long River Delta and caused fires in the U Minh Thuong mangrove forests; the loss was estimated at 5,000 ha of forest, worth 10 billions VND. From 2002–2005, drought occurred in some parts of Vietnam, mainly affecting the south central coastal.

DROUGHT POLICY AND DROUGHT RESPONSE

National Strategy for Drought Risk Management in Vietnam

It is important to realize that combating drought is not the responsibility of just one sector of the country, but instead is an issue that affects and should

Table 3. Cultivating Area Affected by Drought in Vietnam from 1995 through 1999.

Year	Winter–Spring Crop		Summer–Autumn Crop		Full Crop		Whole Year	
	Total area affected by drought (ha)	Total area lost (ha)	Total area affected by drought (ha)	Total area lost (ha)	Total area affected by drought (ha)	Total area lost (ha)	Total area affected by drought (ha)	Total area lost (ha)
1995	151,691	2,816	59,137	5,108	80,722	4,051	291,550	11,975
1996	139,396	6,301	62,018	5,781	59,658	2,260	261,072	14,342
1997	70,911	959	107,871	15,319	91,292	3,802	270,074	20,080
1998	245,547	26,998	369,629	69,401	117,294	15,086	732,470	111,485
1999	66,826	0	0	0	250	0	67,076	0
Total	674,371	37,074	598,655	95,609	349,216	25,199	1,622,242	157,882

Source: Data from the Department of Water Resources and Hydrologic Works Management.

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be tackled by various sectors. The long-term strategy and action plans were prepared and implemented within the 20 years starting in 2002 (SRV, 2002).

According to the Agenda 21, sustainable development is defined as ''to meet the demand of today's generation but not affect the capacity to meet the demand of future generations.'' Therefore, the strategy to cope with drought should consider the different aspects of a socioeconomic development plan. The national strategy for drought management therefore contains not only long-term strategies but also immediate strategies with specific activities. In each phase, the strategy is expected to adapt to meet the specific situation of each period. The process of national plan implementation can be divided into three periods from 2002 to 2021, as follows (SRV, 2002).

Short-Term Strategies, 2002–2005

In order to create basic conditions for the achievement of the mid-term and long-term objectives, the phase 2002–2005 has to concentrate on objectives to meet immediate and urgent needs such as food security, fuel demand, clean water for living, training, and extension as well as to adopt a legal framework for natural-resource management, to do surveys and assessment in desertification in affected and vulnerable areas. This stage also focuses on reforestation, forest protection, land-use management, and water-resource management (SRV, 2006).

Mid-Term Strategies, 2006–2010

During this period, a stable society without hunger and poverty oriented to achieve sustainable development will be set up and step by step general development demands will be met and people will be benefit from advanced science and technology achievements based on traditional knowledge development (SRV, 2007). The main objectives therefore were to speed up the development process of ecologically sustainable, clean, and high-quality agriculture; to diversify products; to combine agriculture, forestry, and processing industries; to modernize and industrialize backward and rural areas; to increase productivity to meet demands and to export; and to improve livelihoods and set up new rural development. Other components were management of the river deltas and watershed areas and protecting water resources, both surface and underground. The dams and irrigation systems were also improved in this period, especially the systems in the Cuu Long River Delta. This period also protected existing forests and extended green areas in bare land by setting plantations, natural regeneration, and agro-forestry development and establishing fruit and industrial plantations in order to achieve 43% of forest cover by 2010.

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Long-Term Strategies, 2011–2021

In this period, Vietnam will achieve sustainable development, all activities have been oriented to strengthen the efficiency of management and utilization of natural resources to meet the demand of social development at new higher levels, the management and science and technological capacity will have synchronized processes and much more development than in the previous phase in all sectors and at all levels (SRV, 2006). In this period, sustainable forestry exploitation based on establishing a balance between forest-resource use and an ecologically safe forest coverage was the first priority; the next was sustainable land use at all levels of landholders or landowners on the principle of upholding the biological productivity of the land with all its ecological and socioeconomic value for the present and future generations and proper reclamation/rehabilitation of degraded land to mitigate its negative effects and give back its original values as a fundamental property for human existence. Others strategies were also concerned with significant improvement in water-resource management; strengthening and updating management capacity and technical facilities for monitoring and evaluating early warning systems to forecast flood and drought in a timely manner; and a significant improvement in rural livelihoods, poverty, hunger, and literacy.

Drought Forecasting and Drought Early Warning in Vietnam

Drought forecasting and early warning contributes to reducing the negative impacts of droughts within a relatively short period. Early indication of possible drought can help to institute drought mitigation strategies and measures in advance. Therefore, drought forecasting plays an important role in the planning and management of water-resource systems.

Index for Drought Forecasting

A drought index is typically a single number that assimilates individual or a combination of different types of data into a comprehensible picture for drought assessment. In trying to define drought, many indicators and drought indexes have been used, such as the Lang index (1915), De Martonne moisture index (1926), Reidel moisture index (1928), Selianinov moisture index (1948), Thornthwaite moisture index (1948) Ivanov moisture index (1948), Budyko dry index (1950), and Penman dry index. Some indexes are better than others for some particular uses (Hayes, 1998).

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A suitable procedure for hydrological dry-season flow forecasting has already been developed within the Mekong River Commission (MRC), which may be the basis for a systematic forecasting system. In August 2005, the MRC finalized a study on drought forecasting and management (Adamson, 2005), which presented a scientific basis for a statistically based forecasting method for hydrological drought onset, specifically for critically deficient dry-season flows on the mainstream.

In Vietnam, there are some indexes that measure certain drought types for a given period based on a single type or a combination of historical data (e.g., the Palmer Drought Severity Index, the Crop Moisture Index, the Standardized Precipitation Index (SPI) and the Surface Water Supply Index (SWSI), and the Dry Index) and they require different types of data to generate. The SPI and SWSI were applied successfully in Vietnam in 2005 on drought definitions and the development of software packages named SPO2005, SWSI2005, and SaI2005. Those software packages have been used for calculating a drought index in Vietnam. HyDF2005 (Meteorological Drought Forecast) is also developed and applied in the central highlands and south central Vietnam.

Process of Drought Forecasting and Early Warning in Vietnam

In Vietnam, drought forecasting and early warning is the responsibility of the Short-Term and Long-Term Drought Forecasting Department of the National Institute of Hydro-meteorological of the Ministry of Natural Resources and Environment (MONRE). This organization receives the daily data observations from all Hydro-meteorological centers at the provincial level and analyzes them before making the decision to issue a drought early warning. Drought early warnings are released by the Institute of Hydro-meteorology at the central level. Information from here will be transferred to the Ministry of Agriculture and Rural Development (MARD), then to the provincial level and mass media for drought preparedness and drought response. The current drought forecasting and early warning system in Vietnam is mono-process and is the responsibility of the Institute of Hydro-Meteorology. Detailed climatic data and drought forecasting information is not provided for free. Normally, the data is purchased by the Department of Agriculture and Rural Development for forest fire warning first and then for drought early warning for agricultural purposes. It is suggested that drought forecasting and early warning systems should be socialized with the contributions of local community and should be provided for free (see Fig. 2).

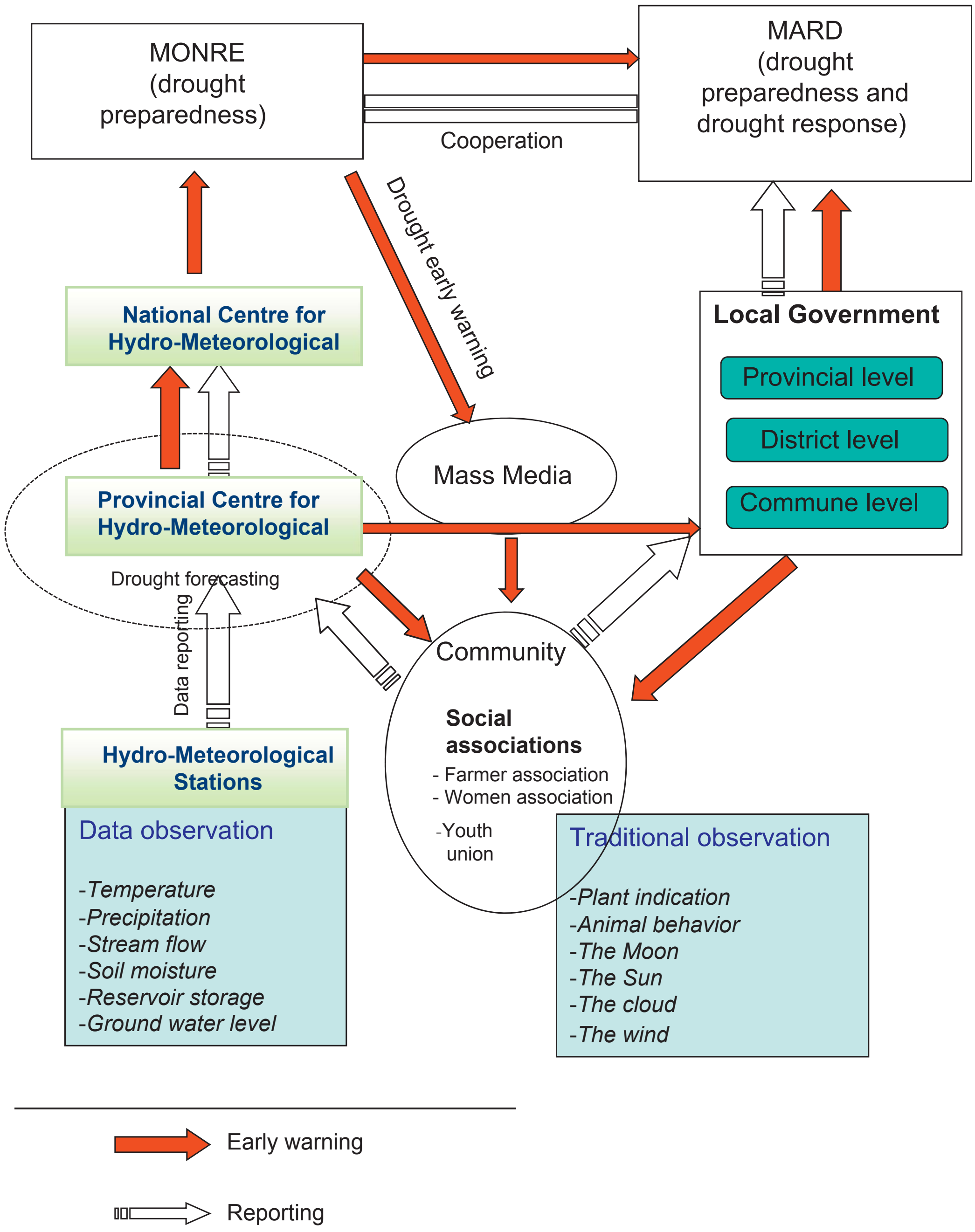

Fig. 2. Proposed Drought Forecasting and Drought Early Warning Process. *Source*: Nguyen (2010b).

Drought communities can contribute to the process of drought early warning and forecasting. Local people can observe and predict weather using their traditional knowledge and report to the forecasting center. Information from local communities should be considered in drought

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forecasting. Fig. 2 describes the proposed institutional framework of drought forecasting and drought early warning processes.

Currently, this activity is the responsibility of the Institute of Hydro-meteorology. The process take time, and occasionally it provides incorrect information, since the analyses take place far away from the drought area. It has been suggested to decentralize the drought forecasting and drought early warning in local centers in the provinces with the participation of local community and local technical staff.

In the proposed drought forecasting and drought early warning process, local communities can play a role in providing information about what they observed from the field, such as the changes in plants, animals, the moon, the sun, and the drying progress of their fields. Information could be report to the local government or directly to the Institute of Hydro-meteorology via their associations. Their information will be combined with the climatic data for drought early warning analysis. Local communities, via their associations, will receive the drought early warning information directly from the Institute of Hydro-meteorology at the provincial level. Local governments can also receive information of drought early warning directly from the Institute of Hydro-meteorology for drought preparedness and planning without payment. At the central level, MONRE and MARD should share information and should in a timely fashion and together develop the action plans for drought preparedness for drought-prone areas in the whole country.

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DROUGHT RESILIENCE MAPPING: CASE OF NINH THUAN PROVINCE

Overview of Ninh Thuan Province

Ninh Thuan is located in the farthest southern part of central Vietnam, with coordinates of 11 deg. 18 min 14 sec to 12 deg. 09 min 15 sec north latitude and from 108 deg. 09 min 08 sec to 109 deg. 14 min 25 sec east longitude bordering Khanh Hoa at the North, Binh Thuan at the south, Lam Dong at the west, and the East Sea at the east. The province has a total area of 3,358 km^2 with 105 km of coastline. The geography is characterized by plains, mountain (with ranges surrounding the province), and coastal areas. The diversified terrain slopes to the east, toward the sea. The capital, Phan Rang, is at the center of the province. There are six districts: Thuan Bac, Thuan Nam, Ninh Hai, Ninh Phuoc (coastal plain districts), Ninh Son, and Bac Ai (mountainous districts) (Fig. 3A). (Department of Statistics of Ninh Thuan Province, 2005).

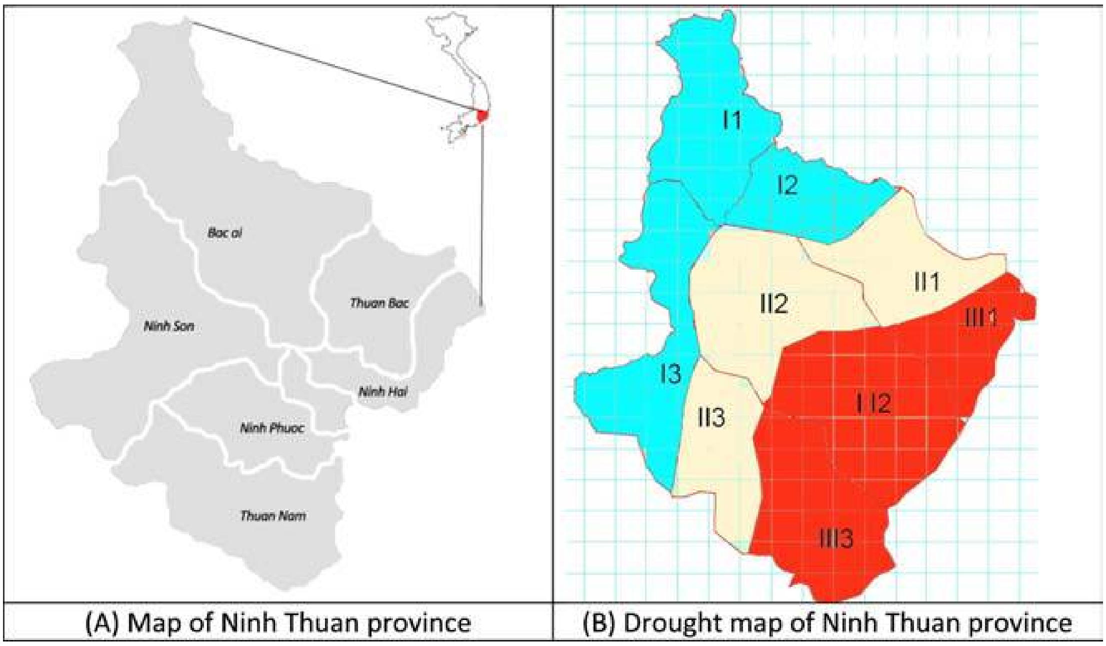

Fig. 3. (A) Administrative Map and (B) Drought Map of Ninh Thuan Province. *Source*: Nguyen (2010b).

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Ninh Thuan province is the hottest province of Vietnam, with an average temperature of about 27°C. The highest temperature recorded was 40.5°C at Nha Ho station in 1937. The lowest temperature recorded was 14°C at Nha Ho station in 1964 and 14.4°C at Phan Rang station in 1931. There are two seasons: the rainy season is from July to November and the dry season from December to June. Normally, the amount of rainfall received is different between the mountainous and the coastal regions. The annual rainfall is 712 mm in the coastal town of Phan Rang–Thap Cham, 1,071 mm in Tan My, and 1,659 mm in Song Pha. The rainfall can reach 2,200 mm/year upstream. The rainy season is strong during the months of September to December.

Ninh Thuan province is divided into three subregions of climate (Nguyen, 2010b). The coastal area (region III) has characteristics of the worst drought area, with average rainfall around 500 to 700 mm per year. This area receives strong winds from the East Sea with hot temperatures almost all year long. The plains area (region II) is also the drought area, with rainfall totals from 750 to 1,200 mm per year, and the mountainous area (region I) has rainfall totals from 1,000 to 1,700 mm per year. Changes in rainfall totals and temperature variations causes subclimate zones to be changed in each 10-year period, changing the drought areas (Fig. 3B).

Drought Resilience Mapping

Drought resilience mapping is an approach developed by Kyoto University (Habiba et al., 2011). With it we can measure the existing level of different environmental, social, and livelihood aspects of the targeted area and how they cope with drought. There are three dimensions for drought resilience mapping. These are Socioeconomic, Institutional and Physical (SIP model). First, the most drought-prone districts were selected, then the questionnaire surveys were answered by the district officers in charge of relevant sectors mentioned in SIP questionnaire. Drought resilience was mapped based on the results from the SIP.

Table 4. Drought SIP Resilience of Ninh Thuan Province.

Districts	Socioeconomic Resilience	Institutional Resilience	Physical Resilience	Overall Resilience
Bac Ai district	2.48	3.04	2.07	2.53
Thuan Bac district	3.83	3.74	3.00	3.52
Ninh Hai district	3.00	3.35	2.79	3.04
Ninh Son district	3.22	2.96	2.00	2.72
Thuan Nam district	3.04	3.43	2.43	2.97
Ninh Phuoc district	3.83	4.39	2.93	3.72
Average in the whole province	3.23	3.49	2.54	3.08

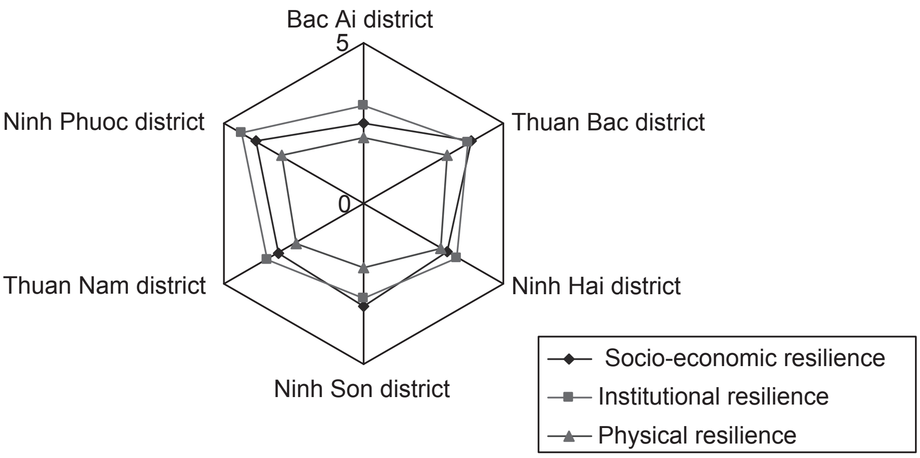

Fig. 4. SIP Resilience in Ninh Thuan Province.

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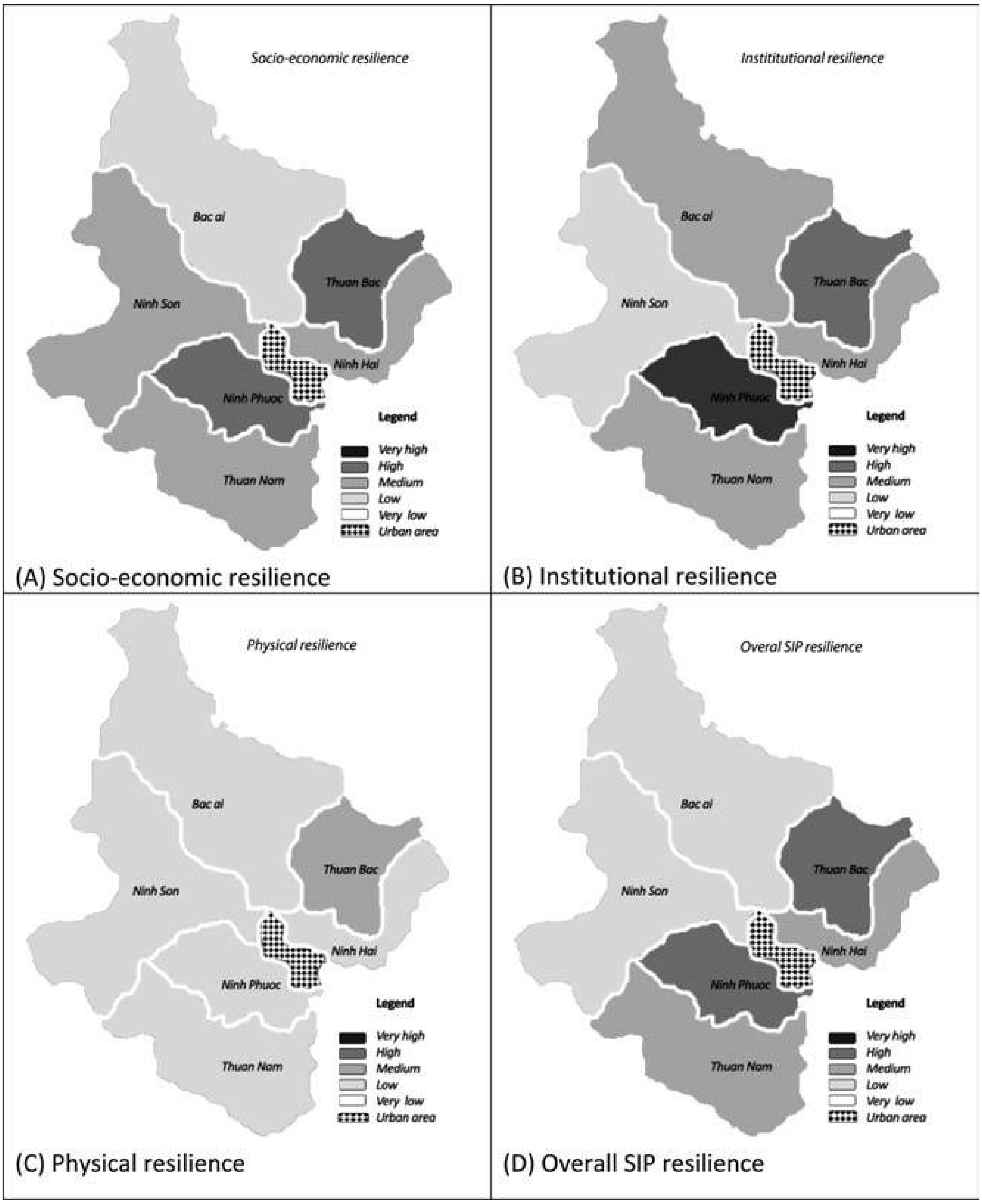

Fig. 5. Drought Resilience Mapping in Ninh Thuan Province. *Source*: Nguyen (2010b).

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Main Findings

The study was conducted in six districts – two located in the mountainous area (Bac Ai and Ninh Son) and the four in the coastal area (Thuan Nam, Ninh Phuoc, Ninh Hai, and Thuan Bac). Socioeconomic resilience indicates the index of education, heath, usage, social capital, and economic issues. The results show that the socioeconomic resilience of Ninh Thuan province is at the medium level (3.13). Bac Ai district has the lowest level (2.48). This mountainous district is the poorest district of Ninh Thuan province (Oxfam, 2005) and the majority of ethnic people (the minority people living in the mountainous areas) live in this area (Shaw et al., 2007). The socioeconomic conditions in this district are lower than in other districts in Ninh Thuan province. Thuan Bac and Ninh Phuoc have high levels of socioeconomic resilience (3.83) and the other three districts have medium levels of socioeconomic resilience (3.00 to 3.22) (Table 4 and Fig. 4).

Institutional resilience indicates the capacity of policy, management, and coordination among local communities, stakeholders, and local governments. In this aspect, Ninh Phuoc district has the highest level (4.39), followed by Thuan Bac, Thuan Nam, Ninh Hai, and Bac Ai; the lowest level is in Ninh Son (2.96).

Physical resilience indicates the index of the infrastructure development, irrigation, and land-use management. The two mountainous districts (Ninh Son and Bac Ai) have low levels of resilience (2.00 and 2.07). The levels in Ninh Hai, Thuan Nam, and Ninh Phuoc are a bit higher. But the physical resilience of these districts is still low, since they are lower than the average index. In this aspect, Thuan Bac district has a medium level of resilience (3.00) (Fig. 5).

DISCUSSION AND CONCLUSION

Considering the SIP results and drought map, it has been shown that SIP resilience in drought-prone areas is higher than in less drought-prone areas. In general, the two mountainous districts have lower levels of SIP resilience, whereas the coastal districts have higher levels. The physical resilience is still low, as Ninh Thuan is ranked as the 53rd poorest province of the total 63 provinces of Vietnam. The poor of irrigation systems in Ninh Thuan province is evidence of this. A part of the drought vulnerability of Ninh Thuan province can be attributed to the lack of adequate surface and subsurface water resources and declining irrigation capacity of irrigation infrastructure (Institute of Irrigation Planning in the South of Vietnam,

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2006). Analysis of available irrigation facilities reveals this fact. The total available design irrigation capacity of 6 irrigation reservoirs and 76 small dams in the province is 25,229 ha. However, they could irrigate only 16,573 ha. Thus, the capacity of irrigation systems can satisfy only 33% of the demand; this is a cause of agricultural drought and hydrological drought in Ninh Thuan province. The weakness and shortcoming of irrigation facilities combined with the lack of rainfall and delayed rainy season are the root causes of hydrological drought in south central Vietnam. As future predictions of DONRE indicate, water demand is increasing and will put more burden on the water resources of Ninh Thuan province (Nguyen, 2010b).

The different dimensions of the SIP method identified the strengths and weaknesses of different sectors of each dimensions of drought resilience mapping for each district, so that governments and other organizations can prioritize policy implications for the sector and can provide inputs for policy formulation. This is also an attempt by which we can measure the overall existing level of drought resilience for the district. It has been suggested that infrastructure development, irrigation, and land-use management (physical condition) need to be improved in the whole province and that education, heath, usage, and social capital need to improve in the mountainous region. As the outcomes from the case study in Ninh Thuan province on the drought resilience mapping, it is suggested that the SIP can be used as planning tool at micro and macro levels.

The local communities themselves have their own capacities that need to be used so they should definitely be involved in the drought risk management process. It is necessary to clarify the gaps, barriers, and challenges of these shortcomings. In addition, there is a need to find the strategies to address those gaps and barriers for decentralizing drought risk management (DRM) policy to enhance community resilience in Vietnam.

Regarding the institutional aspect, it is recommended that decision making engage the participation of local governments, local communities, donors, and other relevant stakeholders with consideration of SIP resilience. Decentralization of drought early warning, drought forecasting, drought preparedness, and drought response needs to be decentralized and spread among the lower levels. Since there are existing gaps on the implementation of DRM at the local level with provincial level and the central government, an institutional platform is necessary for decentralizing the policy-making process (Nguyen, 2010a). It has also been suggested that policy and implementation be combined with specific solutions. Policy and strategy for DRM also need to be considered in the interface between different socioeconomic aspects. Strategy for agricultural sectors need to be integrated with community-based plantations, livelihood diversification, and micro-credit programs in order to enhance local people's resilience to drought and climate change.

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