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WORLD METEOROLOGICAL ORGANIZATION

DeRISK SE Asia
INFO NOTE SERIES

The development of crop decision trees for climate risk management

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KEY MESSAGES

- Crop Decision Trees (CDTs) are an important systematic tool for the development of climate risk responses based on sub-seasonal and seasonal forecasts.
- CDTs are unique in that they combine the need for a harmonized standardized model at the national level with the ability to tailor responses to the local level.
- CDTs generate tailored agricultural advisories to farmers to cope with climate risks occurring at sub-seasonal and seasonal time scales, taking location and crop growth stages into account.
- CDTs can be easily integrated in digital tools and platforms for scaling and automating agro-climatic advisory.

Introduction

Sub-seasonal and seasonal forecasts (SSFs) with sufficient lead time (from 1 month to 6 months) can help farmers to make informed decisions regarding their agricultural activities. The biggest challenge with this is translating SSF information into agriculturally-relevant information that can trigger timely action alerts for farmers and other agricultural stakeholders.

One way to make SSFs useful to the agriculture sector is developing the CDTs based on SSF information for selected crops. CDT will provide recommendations for climate-smart farming practices based on the upcoming 1–6-month SSFs, utilizing mainly rainfall information but also including temperature information in a case-by-case manner. Through sequential scaling down approaches from national to province, district, and commune, location-specific traditional knowledge and valuable experiences on best practices and experiences from local experts and champion farmers can be collected and shared with fellow farmers using the CDT.

In order to use the climate-smart farming recommendations in CDTs, additional key information should be collected, in order to develop a Climate Crop Calendar (CCC) for each crop. A crop calendar is the arrangement of crops according to the chronological order of the crop life cycle and the corresponding crop management practices. The crop calendar can also illustrate some seasonal conditions (start - end time of a crop) and climate variables (monthly rainfall, monthly temperature). A more systematic approach connecting the crop calendar with the seasonal climate conditions and climate-related events during the growth stages of a crop is CCC.

CDT provides proper and timely farming recommendations for a specific crop growth stage (or a specific month) based on SSFs using the information in CCC, where each crop growth stage is linked with farming activities, major climate risks, and major pests and diseases occurring at individual stages. CDTs have been implemented in multiple countries, such as Tonga, Vanuatu, Samoa, Lao PDR, Cambodia, Myanmar, and the Philippines as of October, 2022, through various

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international projects including DeRISK SE Asia. This Info Note will provide a brief description of key processes and guidelines for the development of CDTs, with particular reference to the experiences and lessons learned from the DeRISK SE Asia countries.

Structure of CDT

CDT consists of (i) a CCC with crop growth stages and climate risks, (ii) Seasonal climate (mostly rainfall) scenario-based farming recommendations representing Best Farming Practices (BFPs) available in the target area (national/provincial/district), and lastly (iii) Farming advisories to cope with climate risks taking place at specific crop growth stages.

Crop information

Crop information (see Figure 1) is required to fill the subsequent CCC, seasonal forecast-based farming recommendations, and farming advisories to climate risks.

1) Spatial scale determines whether this crop decision tree is for national, provincial, district, or lower spatial level.

2) Major varieties and their maturity length will need to be identified from those with more than 30% cultivation area (or production) in the target spatial scale. This means major varieties will be targeted, but if the implementing entity determines to go with minor varieties, it can always expand to more varieties.

3) As there are many derivatives for the growth stages of a crop, the crop growth stages should be defined and agreed upon among the implementing entity and the crop experts in the target spatial scale.

4) Farming activities include all agronomic activities that need to be done by farmers during the cropping season. The farming recommendations will be provided in CDT based on the farming activities defined here.

5) Major climate risks affecting crop yield or economic value should be identified in the target

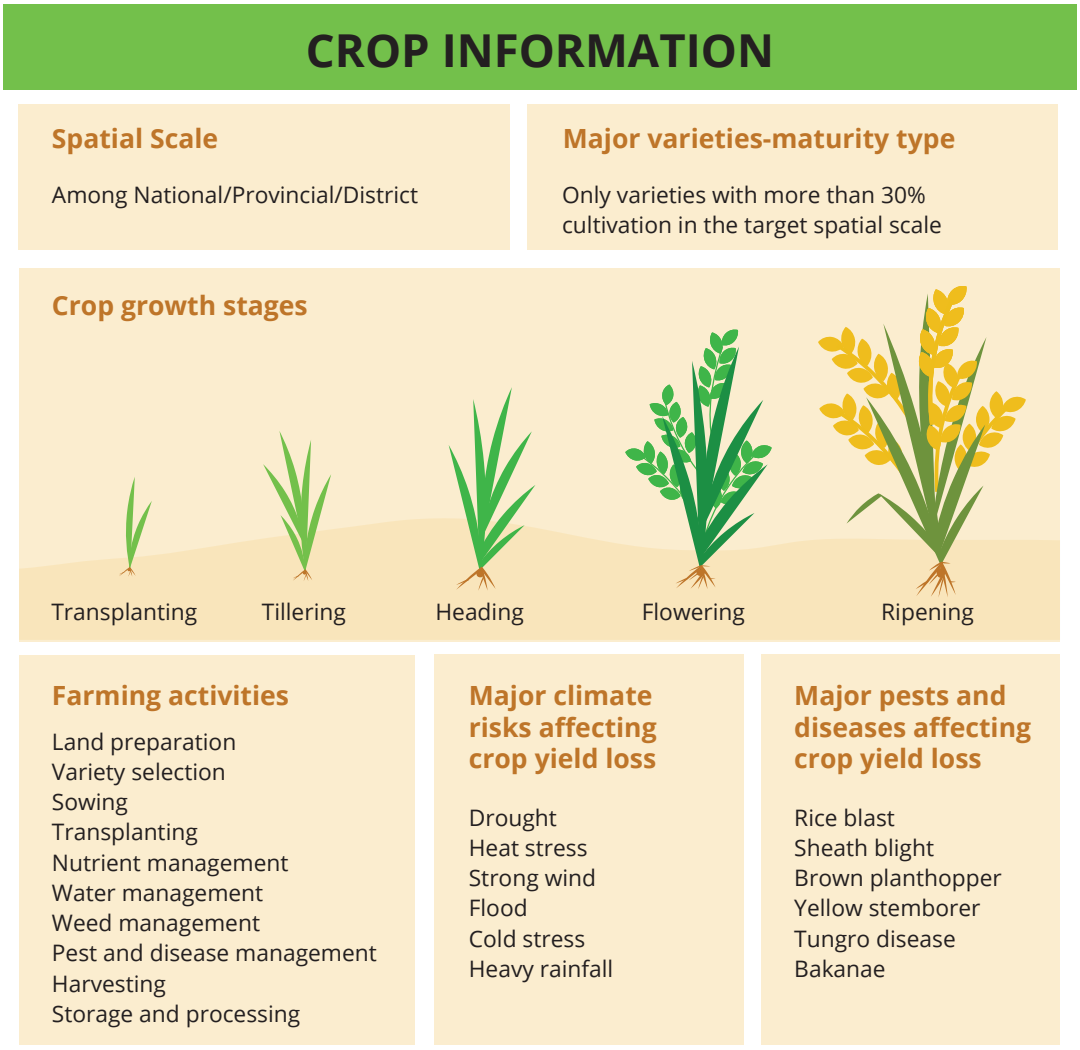


Figure 1. Crop information (rice example)

spatial scale (or locality). On a national scale, the overall climate risks affecting the crop will be listed, but only major ones resulting in economic damage to farmers. On a further local scale (provincial or district), the major climate risks will be varied for each locality, thus needing to be listed differently for each locality. The simplest way of identifying the major climate risks is to recall back last 10 years and select the climate risks that occurred during that time.

6) Major pests and diseases affecting crop yield or economic value should be identified. Each locality will have different combinations of major pests and diseases for the target crop. A simple rule to select major ones will be selecting the ones that had affected more than 5% yield loss over the last 10 years or the ones that had affected more than 20% of crop areas in the target spatial scale.

Climate Crop Calendar

Optimum conditions of rainfall, temperature, wind, sunshine, etc. are required for healthy growth and good yield of crops. But the actual climate conditions during a given crop life cycle, often deviate considerably from the (statistically determined) mean conditions. Therefore, the farmers need to be aware of the potential climate deviations that may affect crops and the appropriate precautionary measures.

Climate Crop Calendar (CCC) (see Table 1) connects the crop growth stages during the cropping season (a fortnight scale) with farming activities, major climate risks, and major pests and diseases. CCC acts as a guide map to select proper farming recommendations (advisories) for timely action by farmers to cope with the seasonal occurrences of climate risks and pests and diseases in the application of CDT. In this way, CCC can help farmers determine when they need to take certain precautionary measures to major climate risks identified for specific growth stages of a crop. In general, CCC comprises:

(i) life history and mean dates of important stages of crop growth;
(ii) list of farming activities, warnings of major climate risks, and pest/disease occurrences, that are dependent on crop growth stage; and
(iii) optimum climate conditions for each stage of crop growth to expect the best crop yield.

Seasonal climate scenario-based farming recommendations

CDT provides farming recommendations (advisories) to farmers based on seasonal climate scenarios, mostly rainfall, from SSFs over the next 1-6 months. In CDT, using only seasonal forecasts, a tercile probabilistic seasonal forecast is used to select the seasonal climate scenario (Box 1). Proper and timely farming recommendations for a specific crop growth stage (or a specific month) are provided based on the CCC, where each crop growth stage is linked with farming activities, major climate risks, and major pests and diseases occurring during the period.

Farming recommendations during the Normal climate scenario (Near Normal tercile from seasonal forecast) refer to locally-adapted good agricultural practices to maximize crop yield and minimize crop loss. These recommendations are mostly based on Best Farming Practices (BFPs) in the target area. BFPs are a series of principles and technical recommendations on the processes of

Table 1. Climate Crop Calendar (rice example)

	JAN		FEB		MAR		APR		MAY		JUN		JUL		AUG		SEP		OCT		NOV		DEC	
	1-15	16-31	1-15	16-28	1-15	15-31	1-15	16-30	1-15	16-31	1-15	16-30	1-15	16-31	1-15	16-31	1-15	16-30	1-15	16-31	1-15	16-30	1-15	16-31
growth stages										s	s	t	t	t	t	f	r	r	r	r				
farming activities									LP	LP SW VS NM	WM	TP WM WD	WD PD NM	WM PD	WM WD	WM PD	PD			HV	ST	ST		
climate risks										D C	D C	D		F	F	D H			W	W	R	R		
pests and diseases										bk	tg bk	rb tg	rb tg		sb	rb sb bp ys	rb sb bp ys	bp ys	ys					

Box 1. Tercile probabilistic seasonal forecast provides the probabilities of each tercile category for a climate variable (rainfall or temperature) based on the forecasts from multiple ensembles of a set of global climate models. Terciles are the 2 values that divide the historical time series record (past 30 years) in three parts leaving 1/3 of the values below the so-called lower tercile value, 1/3 of the values above the so-called upper tercile value and 1/3 of the values between the lower and upper tercile values (Coelho, 2016). In this way, each tercile category have a baseline probability of 33.3% and by definition are expected to occur, on average, once in every three years. When using the seasonal forecasts with CDT, the highest probability tercile among all three terciles (below/near/above normal) or the forecasted tercile by the national met service is used to select the proper farming recommendations in CDT.

planting, growing, harvesting and transportation of food products, that aim towards human health, food security, and protection of the environment to improve the situation of the farmers and their families (Oxfam, 2014). When abnormal climate scenarios (wetter/drier than normal) are predicted from the seasonal forecast, the farming recommendations should be adjusted to cope with the predicted abnormal conditions. Therefore, the implementing agency and the experts should come up with specific farming recommendations by modifying, adding, and removing the farming recommendations for the normal condition, so that they can support the farmer's decisions to minimize the potential crop loss during abnormal conditions (see Table 2).

Table 2. Seasonal climate scenario-based farming recommendations in the part of Crop Decision Tree (CDT) (rice example)

Growth Stages	Farming Activities	Farming advisories (recommendations)		
		Normal Condition (Ideal condition)	Wetter than Normal (Higher than Ideal)	Drier than Normal (Lower than Ideal)
Before sowing	Land preparation	First harrowing and after that filling the field with water at the time of seedbed preparation is needed. Deep ploughing followed by second harrowing should be done. Prior to levelling the field, leave 1-2 inches water depth.	First harrowing and after that filling the field with water at the time of seedbed preparation is needed. Deep ploughing followed by second harrowing should be done. Prior to levelling the field, leave 1-2 inches water depth	Apply less ploughing and harrowing compared to the normal condition is needed. Use alternate wet and dry condition.
	Nutrient management	Phosphorous fertilizer should be applied as basal for the well establishment of roots. First dose of Phosphorous 28 lbs or 56 lbs per acre should be applied during land preparation.	Phosphorous fertilizer should be applied as basal for the well establishment of roots. First dose of Phosphorous 28 lbs or 56 lbs per acre should be applied during land preparation Application of Urea fertilizer is not common because of lodging problem.	Phosphorous fertilizer should be applied as basal for the well establishment of roots. First dose of Phosphorous 28 lbs or 56 lbs per acre should be applied during land preparation
Seedling	Variety Selection and Sowing	Use Shwebo Pawsan under rain-fed condition.	Use Shwebo Pawsan under irrigated condition.	Use drought resistant varieties e.g. Yeanelo (IR-87707-182-b-b-b) released from DAR.
	Transplanting	Transplant the seedlings at the age of 17 – 20 days. The spacing should be 8" x 6" for this variety. Avoid over population of seedlings.	Transplant the seedlings at the age of 21- 30 days. The spacing should be 8" x 4" for this variety. Avoid over population of seedlings.	Transplant the seedlings at the age of 25 – 35 days. Wide spacing of 8" – 10" square should be done. Avoid over population of seedlings.

Table 3. Farming advisories to climate risks (rice example)

Growth Stages	Climate Risks	Farming advisories (recommendations)
Seedling	Drought	Use groundwater and irrigation if available to supply water; use mulch to cover the ground and keep soil moist before planting
	Cold Stress	Polyethene covering of seedbed, deep water irrigation, application of sufficient phosphate will increase cold stress tolerance
Tillering	Drought	Check soil moisture or maintain proper water level; when drought and high temperature are predicted, farmers should look for water source to reserve and beware of water management to keep water for plants in advance
	Flooding (water logging)	Raise ridge, clean drainage ditches to have nothing to be struck on ditches to drain water out during flood; Once flooding, drain water out through ditches to avoid water-trapped; Replant damaged rice
Heading and flowering	Drought	Pump water into field from available sources and beware of water level control
	Heat Stress	Plants need more water in this time so keep water level properly; Apply sufficient nitrogen and deep-flood irrigation to reduce potential heat damage, especially during the reproductive stage
Ripening	Strong Wind	Lodging limits the yield and quality of rice; Minimize nitrogen application to avoid the lodging condition; Remove water from the paddies if possible to minimize the additional damage after lodging
After harvest	Heavy Rainfall	Early harvest and dry immediately; After harvest, the rice should be dried 2-3 days

Farming advisories to climate risks

Farming advisories to cope with major climate risks are collected for the target spatial scale (see Table 3). The climate risks are taking place for specific growth stages, and thus the recommendations should be specific for each growth stage. Although the SSFs generally cover climate risks that develop for a relatively long-term (e.g., drought, excessive wetness, etc), the other climate risks, such as cold/heat stresses and flooding, taking place for shorter terms, are highly correlated with SSF conditions (Vitart et al., 2019), and thus can be prepared with the seasonal farming recommendations when the relevant SSFs are provided. Considering the Ready-Set-Go framework for making use of forecasts from weather to seasonal forecasts (Vitart et al., 2012), weather forecast-based climate risk predictions can also trigger short-term decision making by farmers as going through the cropping season. By the way of developing the farming advisories to major climate risks during crop growth stages, CDT can be used for both seasonal and shorter-term (10-day, weekly) bulletins.

Top-down approach for CDT development

Based on the experiences in many countries, we realized that a top-down approach for the development of CDT, from national to local, is much more effective in many countries. This is reasonably convincing considering the fact that higher education and general and standard knowledge are generally available in the central level, while local specific and more practical and field-oriented knowledge and experiences remain at the local level.

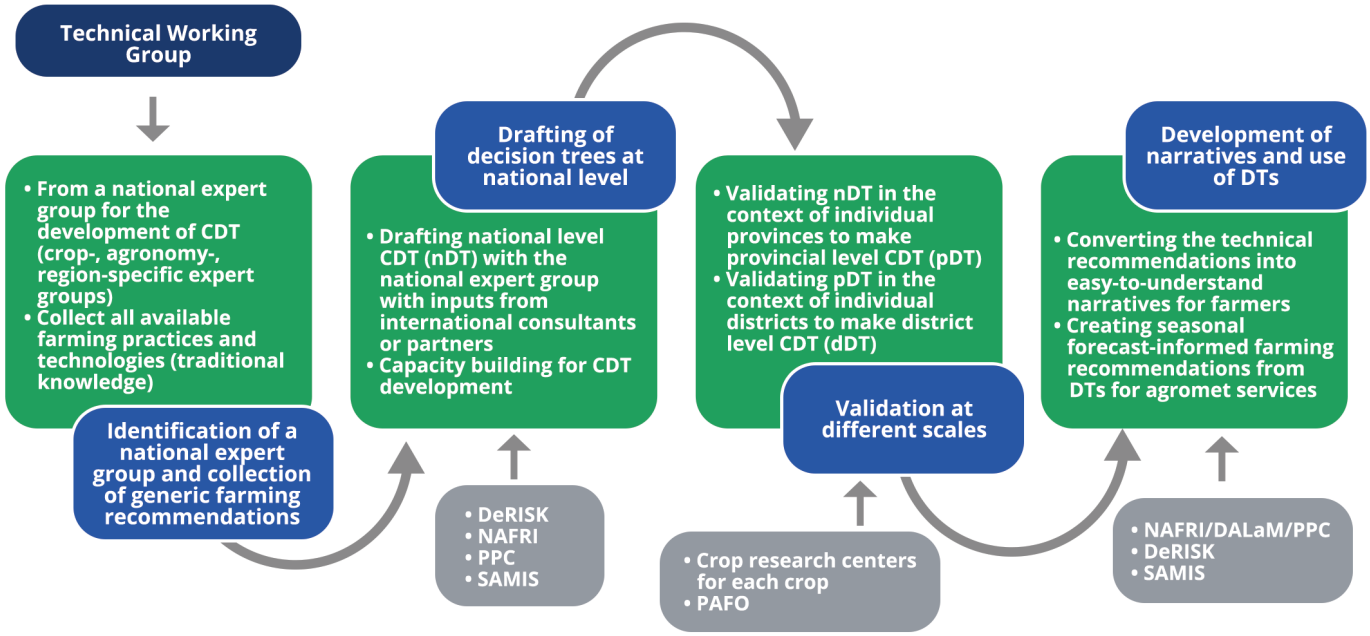
The diagram below (Figure 2) shows an example of developing CDT in Laos through the top-down approach starting from national to local, and the entities that were involved in different scales and their brief roles such as coordinating, drafting, and validating are shown.

1. Identification of a national expert group and the collection of generic farming recommendations for selected crops

Project implementing or coordinating agency identifies the Technical Working Group (TWG), which will guide the overall coordination of the development of CDT.

The TWG, with support from international consultants or external implementing partners, will require multi-stakeholder participation with experts that are familiar with national agricultural systems, particularly focusing on major staple and economic crops in the country, and weather and climate information.

The TWG searches for a national expert group for the development of CDT (crop-, agronomy-, region-specific expert groups). Experts are to be identified at national offices from the Ministry of Agriculture (e.g. crop production, agricultural research institute, national extension office), development partners, representatives from relevant NGOs and other agencies, leading farmers, research institutions, and national universities.



International Level – technical support
- International consultants
- External implementing partners

National Level – Drafting national level CDT (nDT)
- National Agriculture Research Institutes
- Department of Agriculture + Relevant Departments
- Universities, NGOs

Provincial Level – Validating provincial level CDT (pDT)
- Provincial Agriculture Office, Extension
- Provincial Government Unit
- Local NGOs and local universities

District Level – Validating district level CDT (dDT)
- District Agriculture Office, Extension
- Champion farmers

Figure 2. Development process of the Crop Decision Trees through the top-down approach of step-by-step scaling down from national to local (Lao PDR)

The TWG, with a support from the national expert group, identifies target crops and cropping systems and collects all available farming practices and technologies (traditional knowledge), crop calendars from government, literature, or other projects, and historical climate risk-related crop damages that are required for developing pre-draft of CDTs.

2. Drafting of CDTs for selected crops at national level

The TWG trains the national expert group for the development of CDT: The definition of CDT, components and development processes, drafting and validating CDT, etc. Training is very critical in the whole development process, as mis- or wrong understanding of the CDT will lead to almost useless CDT drafts produced by the national experts, thus the training should ensure a correct understanding of participants on CDT and thus its drafting process.

The national expert group drafts national level CDT (nDT) for selected crops, representing major staple and economic crops in the country, with technical guidance from the TWG.

It is recommended that crop-specific experts are among the national expert group. For example, seven expert groups for seven crops, fully considering their crop expertise and preference. If more than two experts can draft the CDT for a crop, then evenly distribute multi-stakeholders from different disciplines for each group, where one can draft and the other can review.

The TWG needs to intervene in the drafting process frequently so that the drafting into the right direction.

Process of drafting CDT

a. Drafting starts from identifying the crop calendar (monthly basis, either national or provincial level) and major climate risks for each crop (monthly basis, specific for crop growth stage).
b. Crop-specific growth stages with the information of average days after planting/sowing need to be defined.
c. BFPs for sequential farming activities (crop/variety selection, land preparation, sowing/planning, nutrient management, water management, pest/weed management, harvest, storage and post-processing) are first described

for specific crop growth stages under the normal climate condition.

d. Based on abnormal climate scenarios from SSFs (e.g., drier than normal, wetter than normal, warmer than normal, cooler than normal), modify the good farming practices, per farming activities and per crop growth stage, to minimize the anticipated damages on crop from the abnormal climate scenarios
e. Review the major climate risks identified with the crop calendar in the beginning, and make sure the adaptive measures to each climate risk per specific crop growth stages are included in the recommendations in the CDT draft; Some climate risks with more short-term events, such as hail, fresh flooding, typhoon, will need to be considered in another agromet product with more short-term weather forecast on 10-day or weekly bulletin.
f. Try to be concise in writing recommendations by putting only key practical advice, thus resulting in a short sentence. Try to avoid too technical/scientific recommendations that are not appropriate for farmers and putting general crop physiology information - Remember this is the agro-advisory, based on which farmers need to take actual action.

3. Validating CDTs at different scales

The TWG searches for a local expert group (e.g., provincial agriculture office, Extension, local universities, NGOs, lead farmers) for the validation of nDT in the context of individual provinces, and train the expert group for the validation of nDT. The local expert group validate nDT to make provincial level CDT (pDT).

For scaling down pDT further to district level, repeat the above processes again: forming local expert group (e.g., district agriculture office, extension, local NGOs, lead farmers) to validate pDT to make district level CDT (dDT).

4. Development of narratives in local language and use of CDTs

The TWG converts the climate-smart farming recommendations of different scales of CDT into easy-to-understand narratives for farmers in the local language.

- Try to be concise in writing narratives by putting only key practical advice, thus resulting in a short sentence
- Try to avoid too technical/scientific recommendations that are not appropriate for farmers
- Try to avoid putting general crop physiology information like a school textbook
- The TWG uses the final CDTs to generate seasonal forecast-informed farming advisories in agromet bulletins.

CONCLUSIONS

- The development of CDTs involves collecting and systemizing local-specific crop information, CCC, and seasonal climate scenario-based BFPs and effective coping practices to major climate risks, with future consideration of the integration of CDTs in digital tools and platforms for scaling and automating agro-climatic advisory.

- CDTs not only provide CCC with crop growth stages and climate risks, and seasonal climate scenario-based farming recommendations, representing BFPs specific to individual crop growth stages and farming activities available in the target area (national/provincial/district), but also farming advisories for farmers to cope with climate risks taking place at specific crop growth stages in the shorter time scale (enabling the use of weather to sub-seasonal forecasts).

- Based on the experiences in multiple countries, including those of the DeRISK SE Asia, the top-down approach, from national to local, resulted in the most effective and efficient process for the development of CDTs for most countries. This is due to the availability of general and standard knowledge in the central level, which could be complemented by the field-oriented knowledge and experiences at the local level.

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The DeRISK SE Asia Info Notes are brief documentation of key processes, initial results, lessons learned, and recommendations based on project implementation with country and regional partners. Please contact the authors for additional information.

The Applying seasonal climate forecasting and innovative insurance solutions to climate risk management in the agriculture sector in Southeast Asia, also known as the DeRISK SE Asia Project, led by the World Meteorological Organization (WMO), co-implemented by the University of Southern Queensland (USQ) and the Alliance, with funding support from the International Climate Initiative (IKI) of the Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV), aims to develop climate risk management systems, best practices, and insurance products that will shield smallholder farmers and businesses across the agricultural value chain in key Southeast Asia countries from physical and financial disaster associated with climate change. It will assist the governments in developing national and regional adaptation and risk management strategies. To know more about our project, please visit: https://deriskseasia.org/.