IMHEN

Viet Nam Institute of Meteorology, Hydrology and Climate Change

Undertake specific downscaling of Drought Index in Viet Nam to district level to support NAP-Ag development

INCEPTION REPORT

2019

1. Approach

Droughts are a normal part of the climate, and they can occur in many regions in Viet Nam. Droughts can arise from a range of hydrometeorological processes that supress precipitation and/or limit surface water or groundwater availability, creating conditions that are significantly drier than normal or otherwise limiting moisture availability to a potentially damaging extent. Droughts are one of the more costly natural hazards on a year-to-year basis; their impacts are significant and widespread, affecting many economic sectors and people at any one time. It therefore will be considered to contribute to strengthening data and information to support screening and prioritization adaptation options of the agriculture sector in Viet Nam. Drought indicators or indices are often used to help track droughts. The Keetch-Byram Drought Index (KBDI) was found to be useful in agricultural contexts because the measure of soil moisture was directly related to drought stress on crops [5, 6, 8]. The globally accepted Keetch-Byram Drought Index (KBDI) therefore will be adopted to downscale Drought Index in Viet Nam to district level.

Drought indices for districts in Viet Nam will be calculted based on maximum temperature and precipitation from 150 meteorological stations. KBDI will be calculated for four seasons in the baseline period. KBDI's change in 2030 and 2050 scenarios compared to the baseline period will be consided. Finally, simulating KBDI for all districts of Vietnam and develop the drought maps. Framework to downscale KBDI to district level in Vietnam is demonstrated in Fig.1.

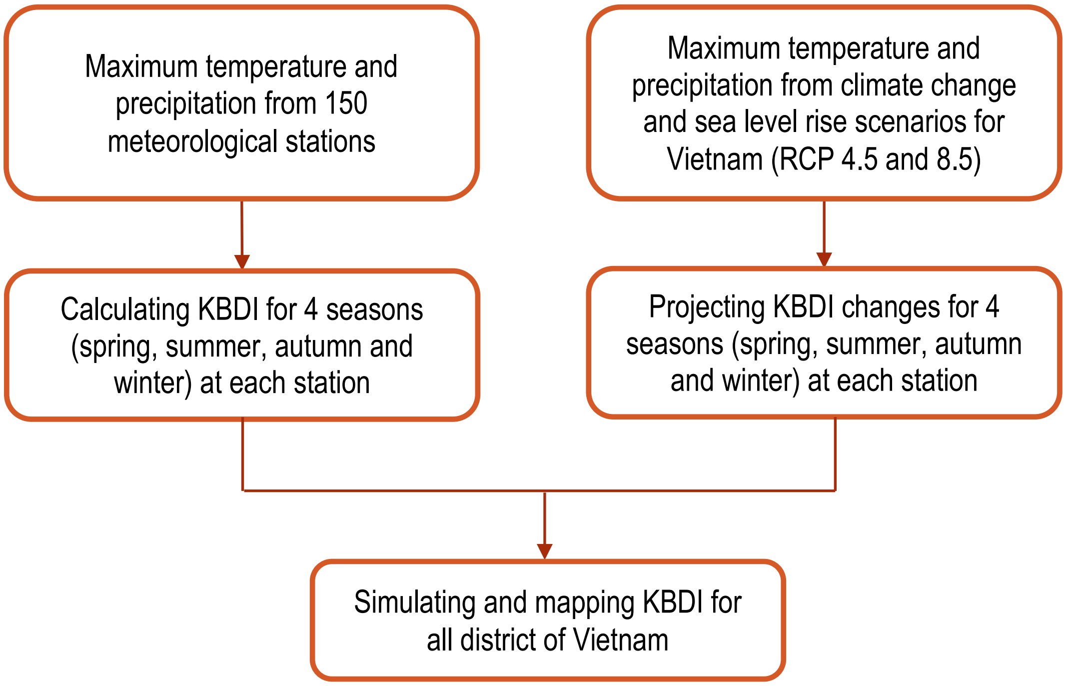

Figure 1. Framework for downscaling KBDI to district level in Vietnam

2. Data

The historic climate data: Observed maximum daily temperature and precipitation over baseline period (1985 to 2015) from 150 meteorological stations in Vietnam will be coleected (list of meteorological stations is shown in apllendix).

The future climate data: Maximum temperature and precipitation from the regional climate models will be adopted from the Climate Change and Sea Level Rise Scenarios for Vietnam, 2016 [3].

3. Methodology

The KBDI is a globally accepted methodology to standardize the drought index and will be adopted to use for the service. KBDI is in essence an indicator of soil moisture deficit and is based on a number of physical assumptions. Soil water transfer to the atmosphere through evapotranspiration is determined by temperature and annual precipitation [6]. KBDI index calculation formula is shown below:

$$dF = \frac{[800 - KBDI_{t-1}]\,[0{,}968e^{0{,}0486T} - 0{,}830]df}{1 + 10{,}88e^{(-0{,}441R)}}\,10^{-3} \qquad \text{(Equation 1)}$$

$$KBDI_t = (KBDI_{t-1} - 100r) + dF \qquad \text{(Equation 2)}$$

Where the symbols, description and units are shown in Table 1:

Table 1: The symbols, description and units used for calculating the drought index, as described in Equations 1 and 2 [1, 2, 5]

Symbol	Meaning	Unit	Symbol	Meaning	Unit
dF	Drought factor	0,01 inch	$KBDI_t$	Moisture deficiency at t	-
T	Maximum temperature	$_o$F	$KBDI_{t-1}$	Moisture deficiency at t -1	-
R	Average annual rainfall	Inch	r	Rainfall day	Inch
dt	Time step	Day			

The number of days with KBDI $\geq$ 200 in each district will be identified. The average number of days that has KBDI $\geq$ 200 in each season over the coincided period (i.e. 1985 to 2015 or in 2030 and 2050) will be used to compare a drought condition between districts. The average values will be classified into different classes that imply from no drought to high drought condition.

The change of KBDI in future for the RCP4.5 and RCP8.5 scenarios (hereinafter, $\Delta \boldsymbol{KBDI_{future}}$) for all districts of Vietnam will be calculated by equation 3 as follow:

$$\Delta \boldsymbol{KBDI_{future}} = \boldsymbol{KBDI^*{}_{future}} - \overline{\boldsymbol{KBDI^*_{1986-2015}}} \quad \text{(Equation 3)}$$

Where: $\Delta KBDI_{future}$ is the change of KBDI in the future compared to the base period

$KBDI^*_{future}$ in the future.

$KBDI^*_{1986-2005}$: The average base period (1986-2015).

4. Construct drought maps for all districts of Vietnam

Since the KBDI at each of 150 meteorological stations calculated, the ArcGIS 10.2 will be applied to construct drought maps for all districts. In this study, drought values at locations without meteorological stations will be interpolated by the Kringing method, which is the default in ArcGIS 10.2 with ordinary kriging [4, 7,9]. Aspatial resolution will be 0.5kmx0.5km. The purpose of the Kriging method is to interpolate the value at one point without a monitoring station by calculating the weighted average of known values in the vicinity of the point .

Kriging assumes that the distance or direction between sample points reflects a spatial correlation that can be used to explain variation in the surface. The Kriging tool fits a mathematical function to a specified number of points to determine the output value for each location. The kriging general formula is formed as a weighted sum of the data [9]:

$$\widehat{Z}\,(S_0) = \sum_{i=1}^{N} \lambda_i \, Z(S_i) \qquad \text{(Equation 4)}$$

where:

Z(s$_i$) = the measured value at the *i*th location

λ_i = an unknown weight for the measured value at the *i*th location

s$_0$ = the prediction location

N = the number of measured values

The kriging method, the weights are based not only on the distance between the measured points and the prediction location but also on the overall spatial arrangement of the measured points. To use the spatial arrangement in the weights, the spatial autocorrelation must be quantified. Thus, in ordinary kriging, the weight, ***λ_i***, depends on a fitted model to the measured points, the distance to the prediction location, and the spatial relationships among the measured values around the prediction location.

Fitting a model is also known as structural analysis, or variography. In spatial modeling of the structure of the measured points are computed with the following equation for all pairs of locations separated by distance h (Eq5):

$$\text{Semivariogram}(\text{distance}_h) = 0.5 * \text{average}((\text{value}_i - \text{value}_j)^2) \qquad \text{(Equation 5)}$$

The formula involves calculating the difference squared between the values of the paired locations. The figure *2* below shows the pairing of one point (the red point) with all other measured locations. This process continues for each measured point.

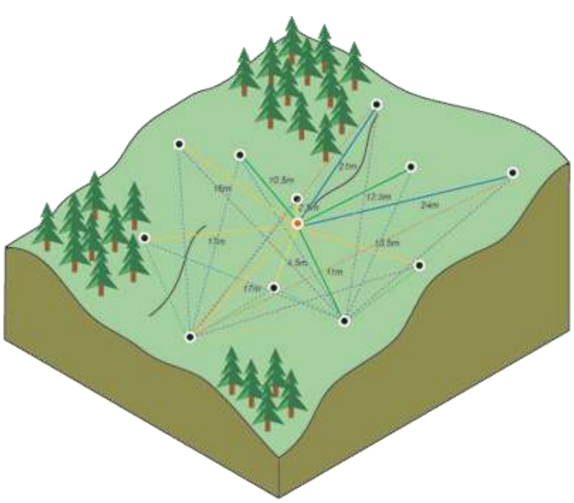

Figure 2: Calculating the difference squared between the paired locations

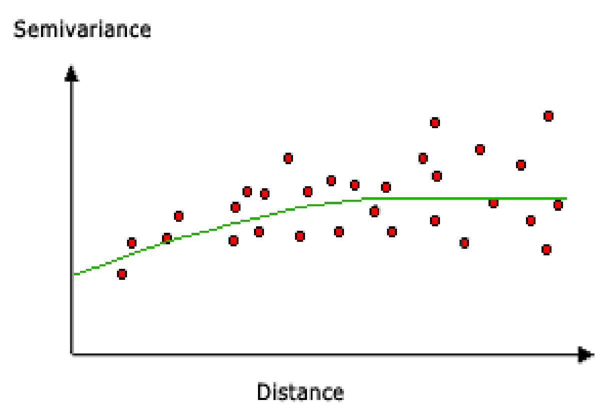

Figure 3: Exponential model example

Often, each pair of locations has a unique distance, and there are often many pairs of points. To plot all pairs quickly becomes unmanageable. Instead of plotting each pair, the pairs are grouped into lag bins. For example, compute the average semivariance for all pairs of points. The empirical semivariogram is a graph of the averaged semivariogram values on the y-axis and the distance (or lag) on the x-axis (Figure 3).

To fit a model to the points forming the empirical semivariogram, semivariogram modeling is a key step between spatial description and spatial prediction. The Kriging tool provides the following functions from which to choose for modeling the empirical semivariogram, such as: Circular, Spherical, Exponential, Gaussian, Linear. In this study, the Gaussian function was used for modeling the empirical semivariogram. This function is the most widely used to interpolate the value of climate in Viet Nam.

The above mentioned methodology will be applied to construct 04 KBDI distribution maps for winter, spring, summer and autumn at the map scale of 1: 1,000,000 for the whole Viet Nam and 16 maps of changes in KBDI at district level for the period of 2030 and 2050 with RCP4.5 and RCP8.5.

References

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Appendix 1. The list of meteorological stations

STT	CODE	NAME OF STATION	PROVINCE
1	48800	LAICHAU	LAI CHAU
2	48802	SAPA	LAO CAI
3	48805	HAGIANG	HA GIANG
4	48806	SONLA	SON LA
5	48807	THATKHE	LANG SON
6	48808	CAOBANG	CAO BANG
7	48809	BACGIANG	BAC GIANG
8	48810	BACKAN	BAC KAN
9	48811	DIENBIEN	DIEN BIEN
10	48812	TUYENQUANG	TUYEN QUANG
11	48813	VIETTRI	PHU THO
12	48814	VINHYEN	VINH PHUC
13	48815	YENBAI	YEN BAI
14	48817	SONTAY	HA NOI
15	48818	HOABINH	HOA BINH
16	48820	HANOI	HA NOI
17	48821	HANAM	HA NAM
18	48822	HUNGYEN	HUNG YEN
19	48823	NAMDINH	NAM DINH
20	48824	NINHBINH	NINH BÌNH
21	48825	HADONG	HA NOI
22	48826	PHULIEN	HAI PHONG
23	48827	HAIDUONG	HAI DUONG
24	48828	HONDAU	HON DAU
25	48829	VANLY	HA NAM
26	48830	LANGSON	LANG SON
27	48831	THAINGUYEN	THAI NGUYEN
28	48832	NHOQUAN	NINH BINH
29	48833	BAICHAY	QUANG NINH
30	48834	COTO	QUANG NINH
31	48835	THAIBINH	THAI BINH
32	48836	CUAONG	QUANG NINH

STT	CODE	NAME OF STATION	PROVINCE
33	48837	TIENYEN	QUANG NINH
34	48839	BACHLONGVI	HAI PHONG
35	48840	THANHHOA	THANH HOA
36	48842	HOIXUAN	THANH HOA
37	48844	TUONGDUONG	NGHE AN
38	48845	VINH	NGHE AN
39	48846	HATINH	HA TINH
40	48847	BADON	QUANG BINH
41	48848	DONGHOI	QUANG BINH
42	48849	DONGHA	QUANG TRI
43	48852	HUE	THUA THIEN HUE
44	48855	DANANG	THANH PHO DA NANG
45	48861	DAKTO	KON TUM
46	48863	QUANGNGAI	QUANG NGAI
47	48865	KONTUM	KON TUM
48	48866	PLEIKU	PLAY KU
49	48867	ANKHE	GIA LAI
50	48870	QUYNHON	QUY NHON
51	48872	AYUNPA	GIA LAI
52	48873	TUYHOA	PHU YEN
53	48875	BMTHUOT	BUON MA THUOT
54	48877	NHATRANG	KHANH HOA
55	48878	BUONHO	DAK LAK
56	48879	CAMRANH	KHANH HOA
57	48880	DALAT	LAM DONG
58	48881	LIENKHUONG	LAM DONG
59	48883	PHUOCLONG	BINH PHUOC
60	48884	BAOLOC	LAM DONG
61	48886	DAKNONG	DAK NONG
62	48887	PHANTHIET	BINH THUAN
63	48888	HAMTAN	BINH THUAN
64	48889	PHUQUY	BINH THUAN
65	48895	DONGPHU	BINH PHUOC

STT	CODE	NAME OF STATION	PROVINCE
66	48898	TAYNINH	TAY NINH
67	48902	BATRI	BEN TRE
68	48903	VUNGTAU	BA RIA - VUNG TAU
69	48904	CANGLONG	TRA VINH
70	48906	MOCHOA	LONG AN
71	48907	RACHGIA	TP. HO CHI MINH
72	48908	CAOLANH	DONG THAP
73	48909	CHAUDOC	AN GIANG
74	48910	CANTHO	CAN THO
75	48912	MYTHO	TIEN GIANG
76	48913	SOCTRANG	SOC TRANG
77	48914	CAMAU	CA MAU
78	48915	BACLIEU	BAC LIEU
79	48917	PHUQUOC	KIEN GIANG
80	48918	CONDAO	BA RIA - VUNG TAU
81	48920	TRUONGSA	KHANH HOA
82	48/01	MUONGTE	LAI CHAU
83	48/02	SINHO	LAI CHAU
84	48/03	TAMDUONG	LAI CHAU
85	48/06	THANUYEN	LAI CHAU
86	48/07	QUYNHNHAI	SON LA
87	48/08	MUCANGCHAI	YEN BAI
88	48/09	TUANGIAO	DIEN BIEN
89	48/10	PHADIN	SON LA
90	48/14	VANCHAN	YEN BAI
91	48/16	SONGMA	SON LA
92	48/17	CONOI	SON LA
93	48/18	YENCHAU	SON LA
94	48/19	BACYEN	SON LA
95	48/20	PHUYEN	SON LA
96	48/23	MINHDAI	PHU THO
97	48/25	MOCCHAU	SON LA
98	48/26	MAICHAU	HOA BINH

STT	CODE	NAME OF STATION	PROVINCE
99	48/30	BACHA	LAO CAI
100	48/31	HOANGSUPHI	HA GIANG
101	48/32	BACME	HA GIANG
102	48/33	BAOLAC	CAO BANG
103	48/34	BACQUANG	HA GIANG
104	48/35	LUCYEN	YEN BAI
105	48/36	HAMYEN	TUYEN QUANG
106	48/37	CHIEMHOA	TUYEN QUANG
107	48/39	CHORA	BAC KAN
108	48/40	NGUYENBINH	CAO BANG
109	48/42	NGANSON	BAC KAN
110	48/43	TRUNGKHANH	CAO BANG
111	48/44	DINHHOA	THAI NGUYEN
112	48/47	BACSON	LANG SON
113	48/48	HUULUNG	LANG SON
114	48/49	DINHLAP	LANG SON
115	48/50	QUANGHA	QUANG NINH
116	48/51	PHUHO	PHU THO
117	48/52	TAMDAO	VINH PHUC
118	48/53	HIEPHOA	BAC GIANG
119	48/55	LUCNGAN	BAC GIANG
120	48/56	SONDONG	BAC GIANG
121	48/57	BAVI	HA NOI
122	48/59	CHILINH	HAI DUONG
123	48/60	UONGBI	QUANG NINH
124	48/61	KIMBOI	HOA BINH
125	48/63	CHINE	HOA BINH
126	48/64	LACSON	HOA BINH
127	48/67	YENDINH	THANH HOA
128	48/69	BAITHUONG	THANH HOA
129	48/70	NHUXUAN	THANH HOA
130	48/72	TINHGIA	THANH HOA
131	48/74	QUYCHAU	NGHE AN

STT	CODE	NAME OF STATION	PROVINCE
132	48/75	QUYHOP	NGHE AN
133	48/76	TAYHIEU	NGHE AN
134	48/77	QUYNHLUU	NGHE AN
135	48/79	CONCUONG	NGHE AN
136	48/80	DOLUONG	NGHE AN
137	48/84	HUONGKHE	HA TINH
138	48/85	LYSON	QUANG NGAI
139	48/86	KYANH	HA TINH
140	48/87	TUYENHOA	QUANG BINH
141	48/89	CONCO	QUANG TRI
142	48/90	KHESANH	QUANG TRI
143	48/91	ALUOI	THUA THIEN HUE
144	48/92	NAMDONG	THUA THIEN HUE
145	48/93	TAMKY	QUANG NAM
146	48/94	TRAMY	QUANG NAM
147	48/95	BATO	QUANG NGAI
148	48/96	HOAINHON	BINH DINH
149	48/97	SONHOA	PHU YEN
150	48/98	MDRAK	DAK LAK

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