FINAL WRITING ASSIGNMENT.

LEELA.G
ASSISTANT EXECUTIVE ENGINEER,PWD,WRO
GAUGING SUB DIVISION.

PARAMBIKULAM DIVISION
PARAMBIKULAM

Distance Learning Course in Hydrology: Advanced Topics in Hydraulics and Hydrological Sciences for the Asian Region (2018)

OPTION:D

Impact of E l Ni no-Southern Oscillation (EN SO), Madden-Julian Oscillation (M JO), or seasonal monsoons in Parambikulam Aliyar Project's chain of Dams and the challenges faced due to variation in precipitation.

SYNOPSIS:

This assignment presents how the rainfall was at Parambikuam Aliyar Project's chain of dams which lies in 'western and eastern slope of Western Ghat at various elevation.

1.Definition of EL Nina.

2.Identifying EL. Nina LA Nino years.

3.Comparing the rainfall received during those years(month wise) for Six dams Viz Upper Nirar weir (UNW),Lower Nirar Dam(LND),Tamil Nadu Sholayar (TNS),Parambikulam (PKM), Aliyar dam, Thirumoorthy Dam.

4.Analysis Result.

5.Challenges faced.

6.Predictions.

7.Conclusion.

In PAP total yield of project envisioned for 50.50 TMC for normal year. From the experience, during last 40 years, yield received is highly uncertain due to various factors such as due to changes in global atmospheric circulation such as El Nino Southern Oscillations, Wind anamoly, Indian ocean SST, Eastern Africa mountains.

1.DEFINITIONS:

El Niño-Southern Oscillation (ENSO)

The vital role of ocean-atmosphere interaction in tropical inter annual variability is illustrated most dramatically by the El Niño-Southern Oscillation (ENSO) phenomenon. ENSO is a "coupled" atmospheric-oceanic process caused by recurring redistributions of heat and atmospheric momentum in the Equatorial Pacific. The zone wise distribution of tropical surface heating (continental and oceanic) produces an east-west circulation pattern known as the *Walker Circulation*. ENSO perturbs the Walker Circulation and triggers major shifts in tropical rainfall patterns and deep convection, disrupting atmospheric circulations and climate across the globe. The extremes of ENSO, termed El Niño and La Niña, encompass a wide range of climatic conditions.

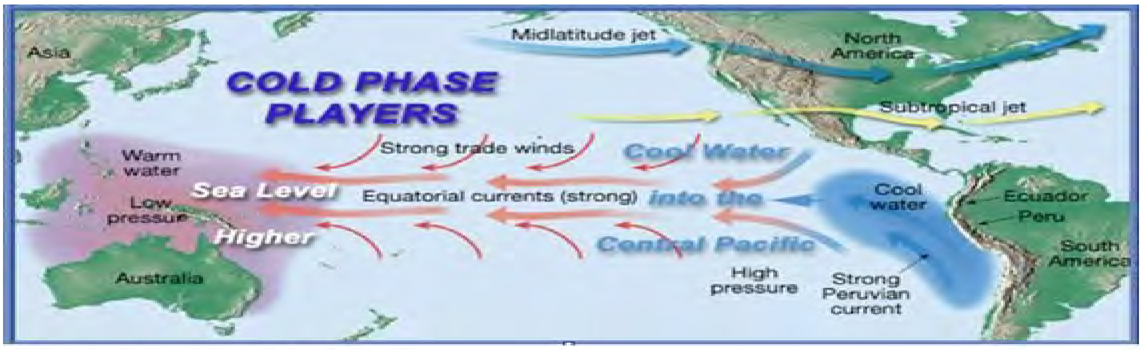
Though ENSO is a single climate phenomenon, it has three states, or phases, it can be in. The two opposite phases, "El Niño" and "La Niña," require certain changes in both the ocean **and** the atmosphere because ENSO is a *coupled* climate phenomenon. "Neutral" is in the middle of the continuum.

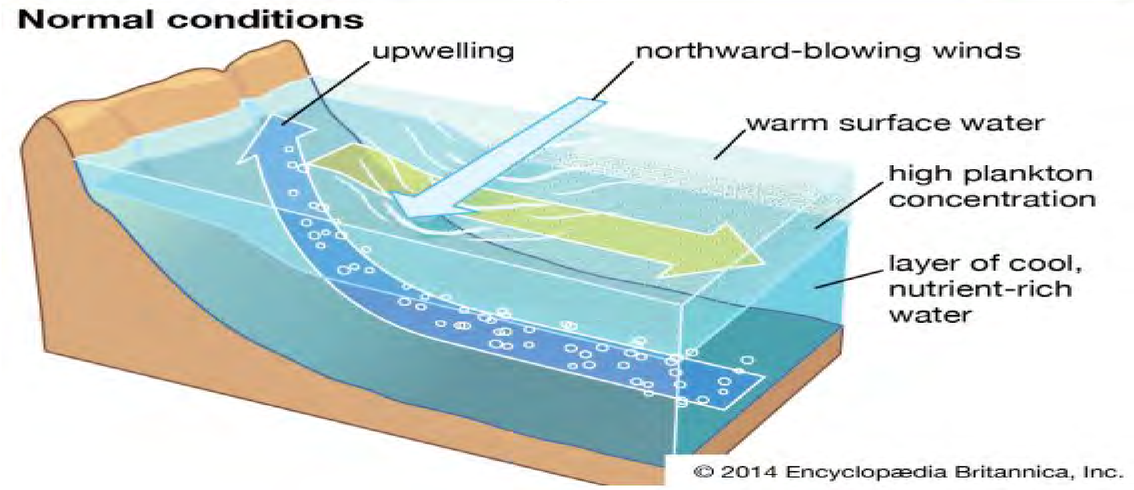
1. **El Niño:** A warming of the ocean surface, or above-average sea surface temperatures (SST), in the central and eastern tropical Pacific Ocean. Over Indonesia, rainfall tends to become reduced while rainfall increases over the tropical Pacific Ocean. The low-level surface winds, which normally blow from east to west along the equator ("easterly winds"), instead weaken or, in some cases, start blowing the other direction (from west to east or "westerly winds").
2. **La Niña:** A cooling of the ocean surface, or below-average sea surface temperatures (SST), in the central and eastern tropical Pacific Ocean. Over Indonesia, rainfall tends to increase while rainfall decreases over the central tropical Pacific Ocean. The normal easterly winds along the equator become even stronger.
3. **Neutral:** Neither El Niño or La Niña. Often tropical Pacific SSTs are generally close to average. However, there are some instances when the ocean can look like it is in an El Niño or La Niña state, but the atmosphere is not playing along (or vice versa).

Due to ENSO, following changes takes across Global oceans and its atmospheres.

During Normal Year or ENSO neutral period following takes place.

- Peru Current = Humboldt Current = Cold Current.
- During normal year two things are “STRONG”
    - Cold Peru Current
- Trade WindsAs a result, cold water is dragged from Peru towards Australia. (From the following image)



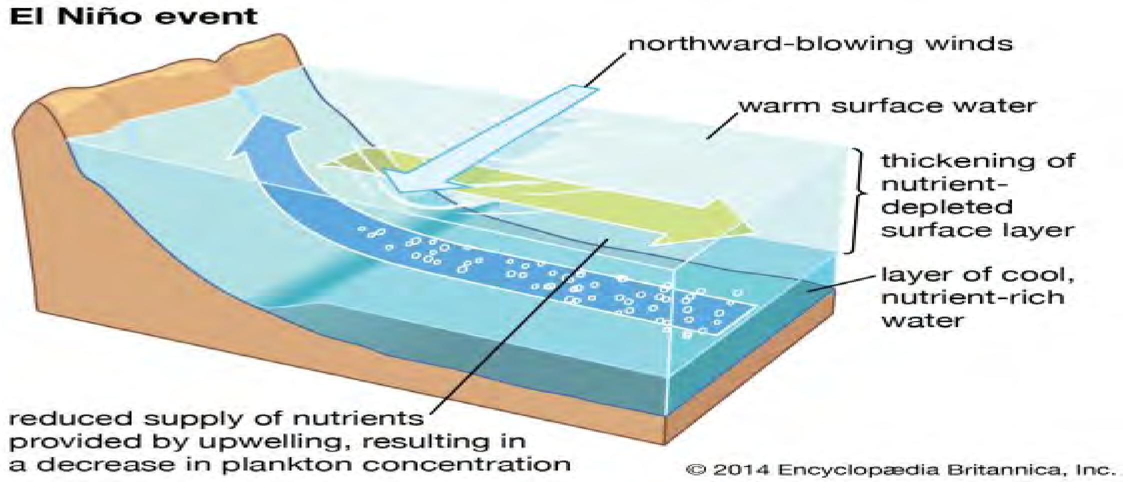


- **Result of this exchange?**
- In above image, the red (warm) water region around Australia is called Western Pacific Pool (WPP)
- WPP = low pressure = warm air ascends = cloud formation = rain over North Australia
- This air also joins walker cell and begins descending near Peru.
- Descending air = anti-cyclonic condition = high pressure = stability = no cloud/rain = Drought in Atacama Desert.

So in a way two cycles are created.

Below the water	**Moving of water from Peru to Australia**	**@Peru cold water upwelling brings nutrient to surface = more lunch for Plankton= more fishes = good for Peru fishermen.**
Above water	Moving of air from Australia towards Peru.	Warm water + low atmospheric pressure = good rainfall over Australia & Indonesia.

- During La Nina years, same things as in a “normal” year, but those two things become even “stronger”
- Cold Peru Current
- Trade Winds
- As a Result?
- Too many fishes @Peru coast, oversupply of fishes= prices become dirt cheap
- Too much rain / flood over Australia and Indonesia.



- During El Nino years , from the above image
- Two things become "WEAK"
  - Cold Peru Current.
  - Trade Winds.

- As result, cold water is not dragged from Peru to Australia.
- But reverse happens - warm water is dragged from Australia towards Peru.
- Consequently, warm water + low pressure condition develops in the Eastern Pacific (Peru) and Cold condition + high pressure in Western Pacific (Australia).

Since Pressure is inversely related with amount of rainfall, the results are following.

- Rain & Floods @Peru, Atkama and even Southern USA
- Drought @Northern Australia, Indonesia- even bushfires.
- Storms and Hurricanes in East Pacific.
- Coral bleaching (high temperature coral dies)

Thus the **El Nino** led to

- Warming of Pacific Ocean
- Near Western coast of Peru and Ecuador.
- Occurs @every 3-4 years; [In theory, it should occur @every 12 years].
- Its impact usually lasts for 9-12-18-24 months.
- It weakens the trade winds and changes in Southern Oscillation, thereby affects the rainfall pattern across the world.

Southern Oscillations are defined by

- Alternating of (tropical) sea level pressure
- Between the eastern and western hemispheres.

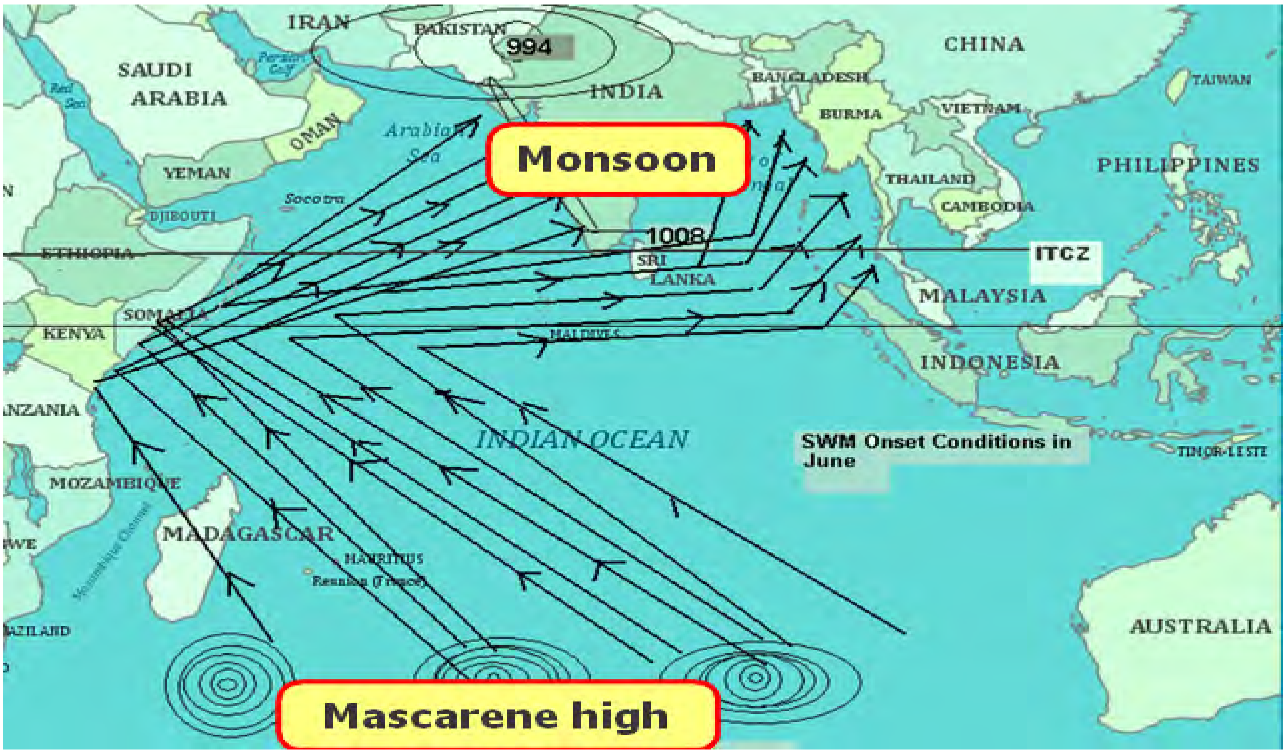
We measure Southern Oscillation by observing the pressure difference between
1. Tahiti (French Polynesia) and
2. Darwin (Australia).

Impact of Southern Oscillation (SO)?

Low SO Index	High SO Index
• Smaller pressure difference between (tropical) oceans • of Eastern vs. Western Hemisphere	• Higher pressure difference between (tropical) oceans • of Eastern vs. Western Hemisphere
associated with El Nino hence the name ENSO = El Nino-Sothern Oscillation, results in generally poor Indian monsoons	La Nina results in generally good monsoons

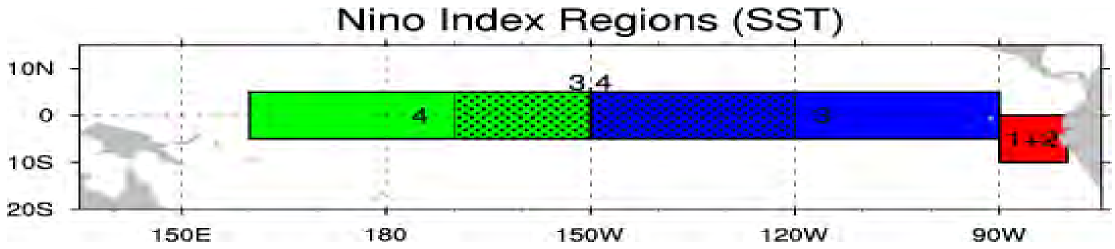
During normal year, the warm water moves towards Australia, this pool of warm water is called Western Pacific Pool (WPP). From WPP air rises above and moves towards two walker cells

1. Towards Peru coast = this affects rainfall in South America.
2. Towards Mascarene High Pressure zone near East Africa. = This affect Indian monsoon.



DURING NORMAL YEAR	DURING EL NINO YEAR
• strong WPP • strong trade winds • strong Mascarene High • Strong push for moisture laden winds towards India good rainfall	• weak WPP • weak trade winds • weakening of winds flowing towards Mascarene high • weak push to Monsoon winds towards India Less rainfall / weak monsoon.
During La Nina years, this push is even stronger = heavy rain and floods.	El Nino caused severe droughts in India

There are several indices used to monitor the tropical Pacific, all of which are based on SST anomalies averaged across a given region. Usually the anomalies are computed relative to a base period of 30 years. The Niño 3.4 index and the Oceanic Niño Index (ONI) are the most commonly used indices to define El Niño and La Niña events. Other indices are used to help characterize the unique nature of each event. The numbers of the Niño 1,2,3, and 4 regions correspond with the labels assigned to ship tracks that crossed these regions. Data from these tracks enabled the historic records of El Niño to be carried back in time to 1949, as discussed in a classic study by Rasmusson and Carpenter (1982).



Niño 1+2 (0-10S, 90W-80W): The Niño 1+2 region is the smallest and eastern-most of the Niño SST regions, and corresponds with the region of coastal South America where El Niño was first recognized by the local populations. This index tends to have the largest variance of the Niño SST indices.

Niño 3 (5N-5S, 150W-90W): This region was once the primary focus for monitoring and predicting El Niño, but researchers later learned that the key region for coupled ocean-atmosphere interactions for ENSO lies further west (Trenberth, 1997). Hence, the Niño 3.4 and ONI became favored for defining El Niño and La Niña events.

Niño 3.4 (5N-5S, 170W-120W): The Niño 3.4 anomalies may be thought of as representing the average equatorial SSTs across the Pacific from about the dateline to the South American coast. The Niño 3.4 index typically uses a 5-month running mean, and El Niño or La Niña events are defined when the Niño 3.4 SSTs exceed +/- 0.4C for a period of six months or more.

ONI (5N-5S, 170W-120W): The ONI uses the same region as the Niño 3.4 index. The ONI uses a 3-month running mean, and to be classified as a full-fledged El Niño or La Niña, the anomalies must exceed +0.5C or -0.5C for at least five consecutive months. This is the operational definition used by NOAA.

The Oceanic Nino Index (ONI) has become the de-facto standard .hence it isused for identifying El Niño (warm) and La Niña (cool) events in the tropical Pacific. It is the running 3-month mean SST anomaly for the Niño 3.4 region (i.e., 5^oN-5^oS, 120^o-170^oW). Events are defined as 5 consecutive overlapping 3-month periods at or above the $+0.5^o$ anomaly for warm (El Niño) events and at or below the -0.5 anomaly for cold (La Niña) events. The threshold is further broken down into Weak (with a 0.5 to 0.9 SST anomaly), Moderate (1.0 to 1.4), Strong (1.5 to 1.9) and Very Strong (≥ 2.0) events. For the purpose of this report for an event to be categorized as weak, moderate, strong or very strong it must have equalled or exceeded the threshold for at least 3 consecutive overlapping 3-month periods.

<u>2.IDENTIFYING EL Nina & LA Nino years:</u>

Based on the Oceanic Nino Index (ONI) , Strong and Weak El Nino ,La Nina years are identified for the world and tabulated below .(from the Water Year 1970-71 onwards)

El Niño				La Niña		
Weak	**Moderate**	**Strong**	**Very Strong**	**Weak**	**Moderate**	**Strong**
1976-77	1986-87	1972-73	1982-83	1971-72	1970-71	1973-74
1977-78	1994-95*	1987-88*	1997-98	1974-75	1995-96*	1975-76
1979-80	2002-03	1991-92*	2015-16	1983-84	2011-12*	1988-89
2004-05	2009-10			1984-85		1998-99*
2006-07				2000-01		1999-00*
2014-15*				2005-06*		2007-08*
				2008-09		2010-11*
				2016-17		

El Niño				La Niña		
Weak	Moderate	Strong	Very Strong	Weak	Moderate	Strong
1976-77	1986-87	1972-73	1982-83	1974-75	1970-71	2007-08
1977-78	1994-95	1985-86	1997-98*	1983-84	2011-12	
1979-80	2002-03	1987-88*	2015-16	1984-85		
2004-05*	2009-10*	1991-92		2005-06		
2006-07*	1973-74	1995-96		2008-09		
2014-15*				1999-00		
1975-76				2010-11		
1988-89						
1998-99						
2013-14						

3.Comparing the received rainfall with average rainfall in EL Nina & LA Nino years.

ENSO events modify PAP region rainfall, sometimes it influences entire PAP Region and in some other times it influence not felt at all. It is identified by rainfall received in the region in the said period and it is tabulated below:

The starred years(refer above table) are El nino Period Even though they are El nino years following stations in the PAP region received Heavy to Moderate rainfall during the said period to due to other local variations.

2004-05	-UNW ,PKM	RECEIVED HEAVY RAINFALL
2006-07	-UNW ,PKM	RECEIVED HEAVY RAINFALL
1979-80	TNS	RECEIVED HEAVY RAINFALL
2014-15	TNS ,PKM	RECEIVED HEAVY RAINFALL
2009-10	-UNW ,PKM	RECEIVED HEAVY RAINFALL
1987-88	TNS	RECEIVED HEAVY RAINFALL
1997-98	LND.TNS	RECEIVED HEAVY RAINFALL

UPPER NIRAR Units are in "mm"

SL. NO	Year	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	Total	STATUS
	AVERAGE	1200	852	85	298	156	48	10	13	48	102	206	985	4428	
1	2009-2010	2583	640	1106	254	162	69	0	0	57	42	89	901	5903	ME
2	1986-87	917	1755	415	345	410	16	4	0	113	75	160	861	5071	ME
3	2004-2005	1067	1624	869	653	316	7	112	7	75	442	240	1103	6515	WE
4	2006-2007	1766	1212	1026	467	339	4	3	0	0	90	322	1959	7188	WE
5	1973-74	1315	1066	0	209	0	32	0	0	0	38	0	400	3060	SL
6	1975-76	785	1688	620	374	202	10	0	2	0	235	48	269	4233	SL
7	1988-89	1013	766	744	64	34	2	0	0	25	154	0	898	3700	SL
8	1998-99	1383	419	673	445	256	130	0	33	0	101	570	446	4455	SL
9	1999-2000	1221	216	306	592	93	5	10	32	0	78	258	931	3741	SL
10	1995-96	0	0	0	240	141	0	29	0	7	161	146	930	1654	ML
11	2016-2017	915	442	174	112	9	20	7	0	160	20	166	699	2724	WL
12	2000-2001	690	15	451	50	103	67	36	18	61	174	233	936	2834	WL

LOWER NIRAR

SL. NO	Year	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	Total	STATUS
	AVERAGE	981	742	415	317	203	39	13	22	53	115	184	747	3830	
1	1997-98	1024	884	397	308	353	140	4	0	22	23	69	935	4159	VSE
2	1979-80	1080	1013	318	271	340	8	0	0	81	200	221	1103	4634	WE
3	2010-2011	801	562	288	401	354	33	0	70	8	91	43	769	3420	SL
4	1988-89	1013	733	719	209	22	46	0	0	23	130	0	723	3618	SL
5	2008-2009	917	608	383	392	65	38	1	0	237	30	202	440	3313	WL
6	2016-2017	693	476	136	121	12	11	30	0	186	40	185	603	2493	WL
7	1995-96	918	706	461	174	169	0	9	2	12	241	176	836	3704	ML
8	2011-2012	580	804	386	367	120	5	0	0	0	122	52	414	2850	ML
9	1983-84	749	729	415	171	175	79	62	26	0	144	21	927	3496	WL
10	2016-2017	693	476	136	121	12	11	30	0	186	40	185	603	2493	WL

TAMILNADU SHOLAYAR.

SL. NO	Year	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	Total	STATUS
	AVERAGE	954	738	429	308	152	41	13	27	79	132	182	835	3889	
1	1997-98	1026	708	417	421	291	132	0	0	8	92	145	787	4026	VSE
2	1987-88	535	819	445	497	324	193	0	60	64	291	117	937	4282	SE
3	2009-2010	1080	465	748	335	242	21	22	0	38	122	120	749	3942	ME
4	2014-2015	1204	1091	482	297	25	72	0	0	0	231	314	1004	4720	WE
5	1979-80	1803	1730	697	247	396	2	0	0	31	216	186	1730	7038	WE
6	1976-77	804	917	331	390	335	50	0	18	107	341	211	692	4196	WE
7	2010-2011	766	439	238	253	295	18	0	29	24	116	68	961	3207	SL
8	1999-2000	852	486	137	448	64	0	5	32	320	180	215	700	3439	SL
9	1973-74	927	711	104	268	135	0	0	625	4	0	0	324	3098	SL
10	1975-76	639	1319	590	392	189	2	0	0	6	207	89	279	3712	SL
11	1995-96	949	717	515	207	122	0	10	8	3	223	49	585	3386	ML
12	2011-2012	577	735	538	184	249	6	0	0	7	142	33	460	2931	ML
13	2008-2009	780	618	541	323	55	20	3	0	38	12	96	400	2886	WL
14	2016-2017	958	302	127	57	20	17	2	0	126	41	261	636	2547	WL
15	1971-72	770	617	444	299	27	134	0	0	0	76	491	487	3345	WL

PARAMBIKULAM

SL. NO	Year	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	Total	STATUS
	AVERAGE	516	355	213	253	123	23	5	16	49	112	138	448	2250	
1	2009-2010	1386	381	426	286	218	4	0	0	8	92	47	689	3537	ME
2	2004-2005	377	472	53	232	267	0	11	0	59	359	258	460	2548	WE
3	2006-2007	637	548	488	285	235	0	7	0	0	210	115	778	3303	WE
4	2014-2015	862	832	324	314	34	8	0	0	0	237	53	360	3024	WE
5	1988-89	275	444	332	39	6	0	2	0	28	55	74	373	1628	SL
6	1998-99	523	120	318	350	126	132	0	4	2	79	279	288	2221	SL
7	2016-2017	387	130	15	36	4	38	0	0	173	120	169	443	1515	WL
8	1995-96	440	276	228	91	76	0	7	2	25	224	57	274	1700	ML
9	1983-84	350	385	214	69	33	42	0	4	36	94	112	534	1873	WL
10	1984-85	448	128	99	187	17	58	88	0	8	59	97	667	1857	WL

ALIYAR DAM

SL. NO	Year	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	Total	STATUS
	AVERAGE	96	70	51	160	161	46	7	10	21	57	76	80	836	
1	1987-88	23	59	100	294	149	205	0	0	11	282	293	40	1455	SE
2	1994-95	154	63	71	270	254	0	0	0	11	90	70	52	1034	ME
3	1997-98	77	93	45	295	289	50	0	0	0	135	75	98	1156	VSE
4	2015-16	85	170	76	92	177	121	0	0	22	17	119	59	936	VSE
5	2016-17	29	2	5	97	16	26	3	0	61	96	103	63	501	WL

THIRUMOORTHY DAM

SL. NO	Year	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	Total	STATUS
	AVERAGE	41	27	55	169	179	88	9	8	16	44	61	36	734	
1	1987-88	14	22	36	263	79	248	0	0	21	77	141	25	926	SE
2	1994-95	64	3	73	168	300	3	6	0	10	134	109	34	902	ME
3	2002-2003	7	55	45	324	50	122	0	6	70	51	0	15	744	ME
4	2014-2015	37	53	112	257	115	29	0	0	0	135	157	66	961	WE
5	1973-74	79	9	11	16	53	181	0	0	3	7	0	8	365	SL
6	1975-76	67	30	226	21	64	53	0	0	0	94	7	0	560	SL
7	1988-89	60	44	21	64	72	7	0	0	22	71	31	11	403	SL
8	2016-2017	16	1	0	116	13	52	10	0	27	52	58	16	360	WL

4.Analysis Result:

In the above table during moderate and weak El nino period some dams received more than the anticipated average rainfall. In La nina period received rainfall were lesser than the anticipated rainfall.

5.Challenges faced.

Water Budgeting can't be done based on El nina /La nino,Local climatic data has to be collected and separate study has to be done.2016-17 is practically very acute drought year but 2016-17 was weak La nino.Likewise sudden rainfall during EL nina also left water managers in critical condition.

6.PREDICTIONS:

we will observe the basic root and foundation, the initial 4 parameters only, and the initial seed of the monsoon. From these parameters, later a few more develop.

1. Cross Equatorial Winds from Southern Hemisphere.

2. Seasonal Low over India/Pakistan.

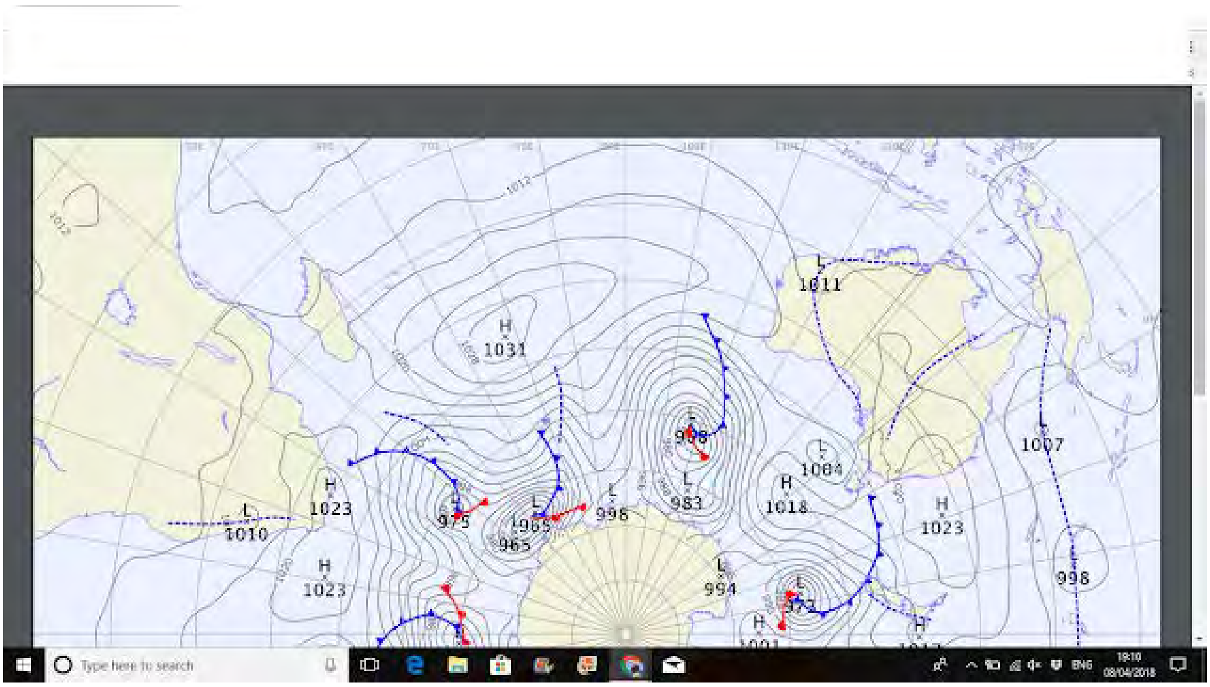
3. ENSO Status.

4. Pre Monsoon Low in the Bay.

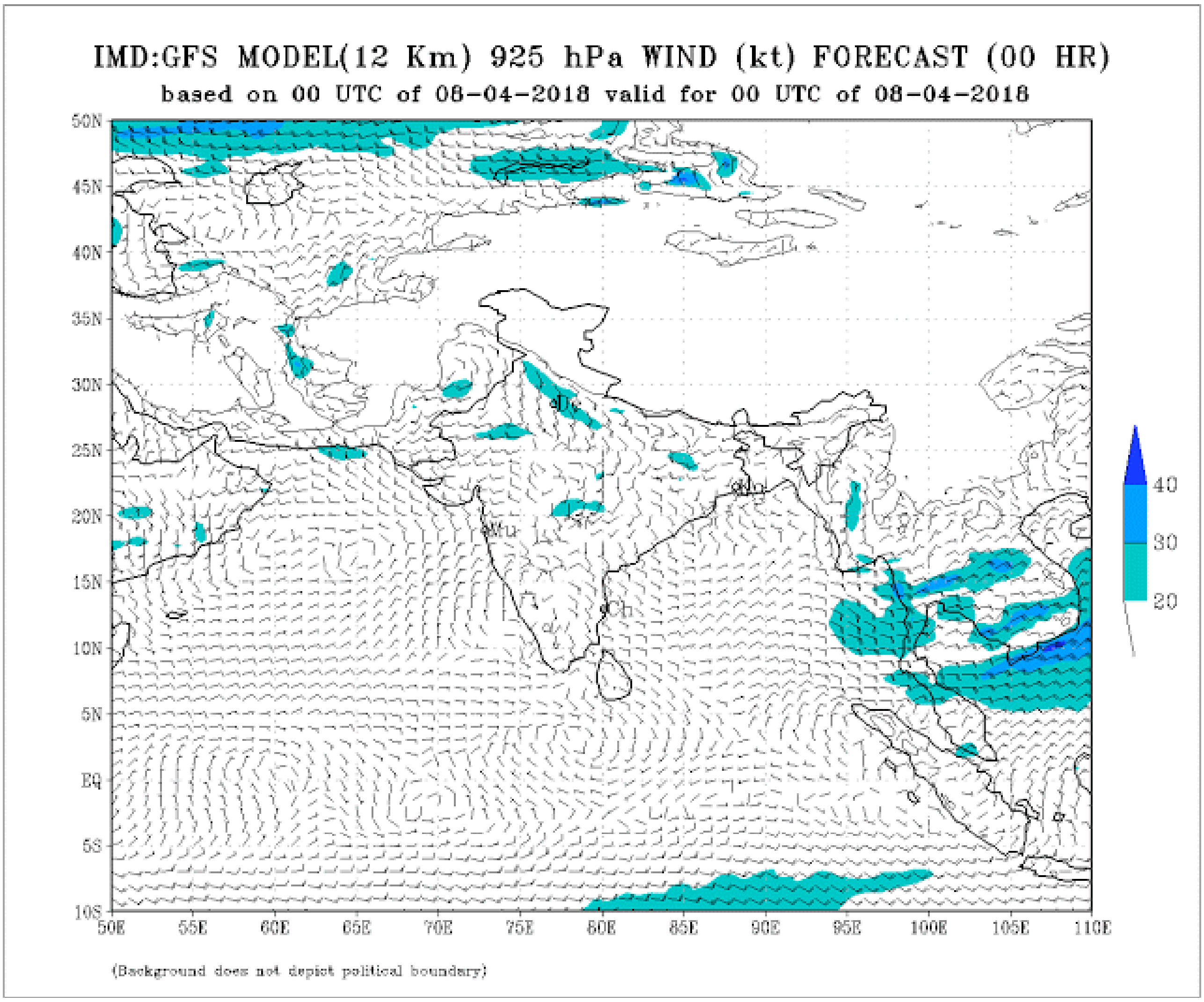
1. Cross Equatorial Winds:

The Mascarene Highs are the main "Power House" of the South -West Monsoons. This generates the South -East winds, which after gaining strength, cross the equator and become south west. For a proper High to form in the South Indian Ocean, the cyclone season (Low pressures) should completely die down from that region.

As on date today, the Mascarene Highs is forming in the required region. A small High at 1031 mb. Four "weak" Lows are tracking in the region. We have to wait for these "lows" to dissipate.



But things are unorganised below the Equator.(Wind Chart Below)
Cross Equatorial Winds should start forming, and taking shape from mid -April, especially in the South Indian ocean region.
Initial forming of SE winds off the East African Coast has not started from below the equator. Weak Easterly flow below Sri Lanka (in the Southern Hemisphere) can be see, though a bit dis-organised.



ITCZ:This Seasonal trough passes from the South Arabian Sea to Andaman sea after the withdrawal of SWM in Oct. Shifts further south in Dec. Moves North during SWM

Now near the equator.

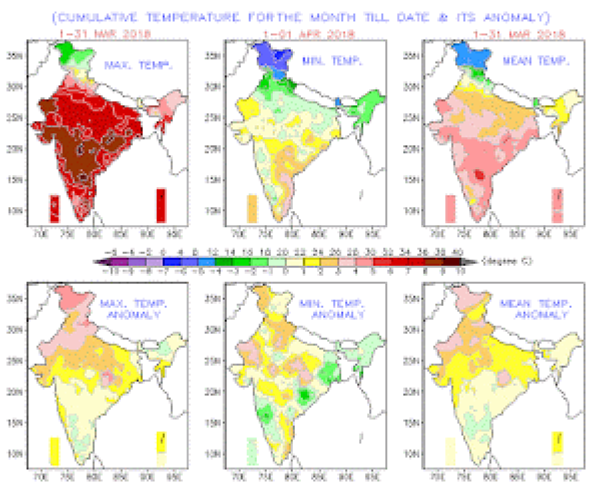
Today, the winds North of the Equator are Northerly (around a "high") in the Arabian Sea, ... and are Easterly in the South of the Arabian Sea.

As the Monsoon strikes the Andaman Sea by mid May, developing wind currents (Westerly) are required to be observed initially near the Eastern side of the Southern Indian Ocean, and this is not forming as of today, Southerly flows are required to strike Sumatra.

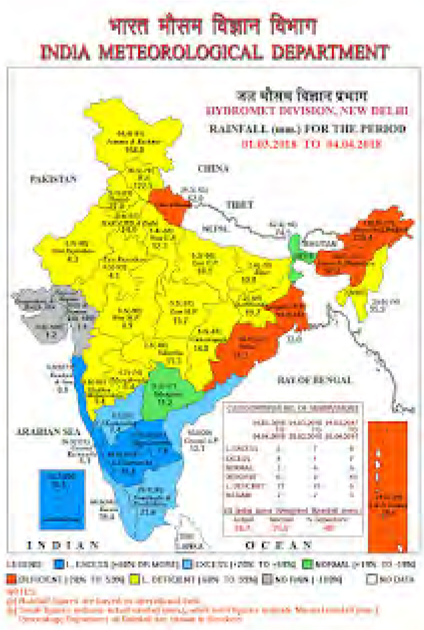
Indicator: -ve

2. Seasonal Low: Now, this year, the heating in the sub continent has started from March , with Heat Waves in Maharashtra, Gujarat, Central India and parts of NW India.. The above normal heating in many parts continues in April.

On an average, March has registered normal temperature (average day and night),



and, with below normal rainfall...-48%. These are a points in the formation, or a quicker formation of one of the important pre monsoon weather requirement, the seasonal low.



In June,the seasonal low, which stretches to Arabia from India, normally starts forming in the Barmer and adjoining regions in the second week of April.

7.CONCLUSION:

For tropical countries like India,the distance plays a vital role.Along with El nina & LA nino Wind anamoly,Indian ocean SST,Eastern Africa mountains,Pressur points in Mauritius etc as well as the Orography of the local area decides the Monsoon,Precipitaion and its Intensity. The result is ONE TO MANY.

REFERENCES

1. https://www.meted.ucar.edu/training_module.php?id=486#.Wug2wdSux1s
2. https://www.meted.ucar.edu/tropical/textbook_2nd_edition/navmenu.php?tab=4&page=4.0.0
3. https://www.meted.ucar.edu/tropical/textbook_2nd_edition/navmenu.php?tab=5&page=0.0.0
4. http://www.meted.ucar.edu/tropical/textbook_2nd_edition/navmenu.php?tab=6

Thanks to

1. Mr.Guhan,Meteorologist,IMD,Chennai.
2. Mr.Rajesh Kapadia http://www.vagaries.in/2018/04/monsoon-watch-1.html