

Putmanagement avonturen in Mandalay



Rob Lafort
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Opbrengsten studiereis



- Uitbreiding van kennis en inzicht in de ontwikkelingen op het gebied van putmanagement
- Het kennisnetwerk is door contacten met Nederlandse en buitenlandse collega's/deskundigen versterkt.



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Main issue

The deep tube (1-27) wells along the Ayeyarwaddy have decreased in capacity. Of the design capacity of approximately 105.000 m³/day to 112.000 m³/day only 65.000m³/day still remains. This means that nearly **40% of the deep tube well's capacity has been lost** over the years.



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Objectives of this assessment.

Explore in a quick-scan the options to improve the capacity of the 27 existing deep tube wells that are located near the Ayeyarwaddy river. Questions that need to be answered are:

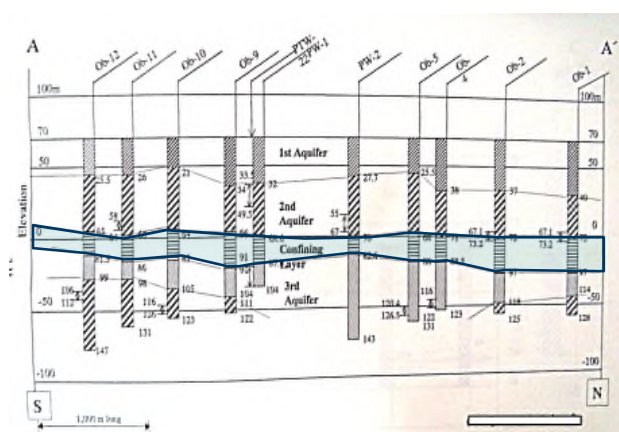
- Is there **mining of the groundwater resources** going on. Are these groundwater extractions exceeding the volumes of a natural recharge. Are the water tables falling?
- Is there some **well clogging**? And if yes. what are the **characteristics of this clogging**?
- Are there some **defects or other limitations** on the wells, the well pumps, the transportsystem that limits the capacity of the groundwater extraction system?
- Or might there be a **combination** of the above described causes?



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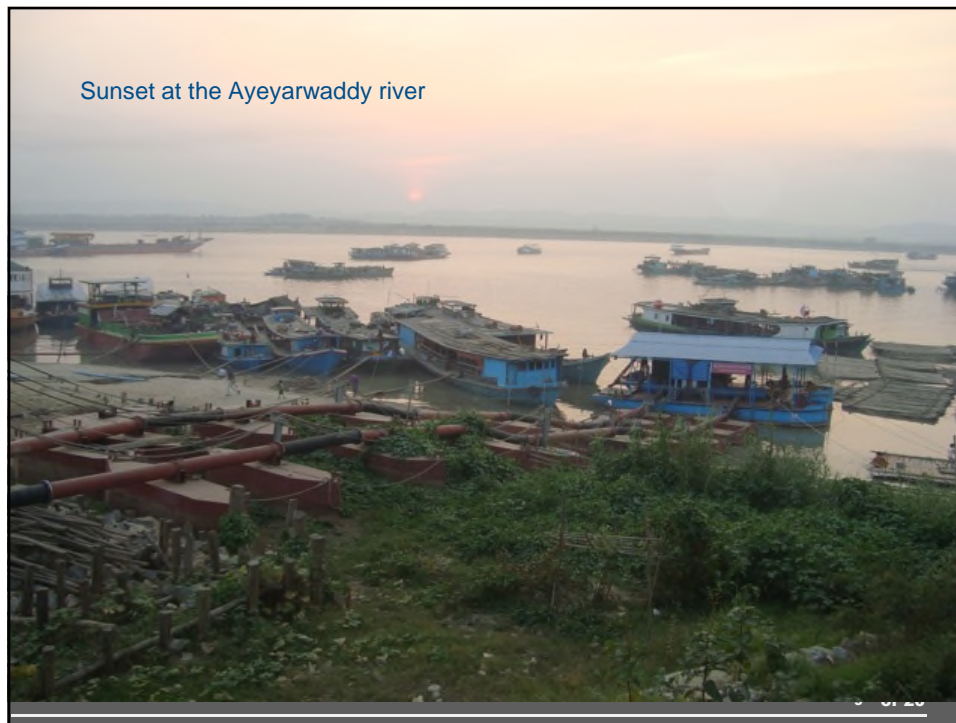
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Hydrogeological system Mandalay (according JICA report)



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Different views on the effects of the groundwaterextractions on the hydrogeological system

What do earlier studies say?:

- A Hydrogeological study of 1989 of the Mandalay watersupply project says:
 - The amount of stored groundwater is enormous, depletion of the groundwater supplies is unthinkable. An extraction of 87.000m³/day is unreservedly applicable.
- The ADB study of the early -90's says:
 - The existing tubewells will be recharged by the Ayeyarwaddy river. (which can be considered as a main and always available source). Further expansion is possible and should be considered in the 2nd instead of the 3th aquifer.
- The JICA report of 2003 says:
 - The yearly extraction of 170.000m³/day (which includes the approximately 22.000 private wells in Mandalay nowadays) over exceeds the natural recharge (107.000m³/day - 118.000m³/day).

So is this groundwater extraction system sustainable or not? Different studies, different answers.

Some data of MCDC's tubewells

Tube well (no.)	JICA depth screen m - surface	JICA length screen m	MCDC pump type	MCDC depth pump m - surface	MCDC design cap. m ³ /day	JICA report 2003 m ³ /day	MCDC 7-2-2014 m ³ /day	Safage m ³ /day	MCDC/VEI 18-5-2014/30-5-2014 m ³ /day
10.PTW1	128 - 146,3	18	Submersible	41,37	4320	4500	4968	6720	3634
10.PTW2	98,3 - 116,6	18	Vertical pump	35	4320	4500	5184	4560	4270
10.PTW3	123,3 - 141,6	18,3	Vertical pump	35	4320	4500	4320	3240	3543
10.PTW4	98,9 - 117,2	18,3	Vertical pump	35	4320	4500	5352	4320	4452
10.PTW5	121,4 - 140,2	19	Submersible	41,37	4320	4500	2832	3840	3725
10.PTW6	103,7 - 122	18	Submersible	35	4320	4500	4848	4080	4088
10.PTW7	128,4 - 146,7	18	Submersible	49,96	4320	4500	4728	3600	3907
10.PTW8	112,6 - 130,9	18	Submersible	44,55	4320	4500	1757	0	0
10.PTW9	107,5 - 113,6	6	Submersible	46,14	4320	4500	4656	3360	3907
10.PTW10	100,6 - 106,7	6	Vertical pump	35	4320	4500	1920	0	1454
10.PTW11	105 - 111	4	Vertical pump	35	4320	4500	4200	3840	3543
10.PTW12	123,3 - 129,4	6	Vertical pump	35	4320	4500	480	0	118
10.PTW13	111,5 - 129,8	18	Submersible	42,96	4320	4500	2928	0	0
10.PTW14	109,7 - 115,8	6	No pump installed	50,92	4320	4500	0	0	0
10.PTW15	99,7 - 105,8	6	Submersible	47,74	4320	4500	1080	0	0
20.PTW.16	90,9 - 109,2	18	Vertical pump	36,6	4320	4500	312	0	273
20.PTW.17	115,2 - 117,6	2,47	Vertical pump	35	4320	4500	0	0	0
20.PTW.18	86 - 104,3	28,3	Vertical pump	35	4320	4500	5040	5260	4179
20.PTW.19	93,8 - 106	12,2	Submersible	48	4320	4500	456	480	372
20.PTW.20	93,6 - 111,9	18,3	Submersible	35	4320	4500	2568	0	2180
20.PTW.21	102,7 - 121,6	18,9	Submersible	35	4320	4500	5400	3840	4542
10.PTW.22	114,5 - 132,8	18,3	Submersible	50	4320	4500	4992	6000	4179
10.PTW.23	114,5 - 132,8	18,3	Submersible	60	4320	4500	0	3840	0
10.PTW.24	121,8 - 140,1	18,3	Submersible	35	4320	4500	0	0	0
20.PTW.25	126,3 - 144,6	18,3	Submersible	35	0	0	2880	3240	2271
20.PTW.26	135,1 - 141,2	6	- ?	48,7	4320	4500	0	2880	5360
20.PTW.27	105,6 - 123,9	18	- ?	48,7	4320	4500	0	3960	5360
Total					112.320	117.000	70.901	67.060	65.357

Some more data of MCDC's tubewells

Tube well (no.)	JICA depth screen m - surface	JICA length screen m	MCDC pump type	MCDC depth pump m - surface	MCDC design cap. m ³ /day	JICA report 2003 m ³ /day	MCDC 7-2-2014 m ³ /day	Safage m ³ /day	MCDC/VEI 18-5-2014/30-5-2014 m ³ /day
10.PTW1	128 - 146,3	18	Submersible	41,37	4320	4500	4968	6720	3634
10.PTW2	98,3 - 116,6	18	Vertical pump	35	4320	4500	5184	4560	4270
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10.PTW6	103,7 - 122	18	Submersible	35	4320	4500	4848	4080	4088
10.PTW7	128,4 - 146,7	18	Submersible	49,96	4320	4500	4728	3600	3907
10.PTW8	112,6 - 130,9	18	Submersible	44,55	4320	4500	1757	0	0
10.PTW9	107,5 - 113,6	6	Submersible	46,14	4320	4500	4656	3360	3907
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10.PTW13	111,5 - 129,8	18	Submersible	42,96	4320	4500	2928	0	0
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10.PTW15	99,7 - 105,8	6	Submersible	47,74	4320	4500	1080	0	0
20.PTW.16	90,9 - 109,2	18	Vertical pump	36,6	4320	4500	312	0	273
20.PTW.17	115,2 - 117,6	2,47	Vertical pump	35	4320	4500	0	0	0
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20.PTW.20	93,6 - 111,9	18,3	Submersible	35	4320	4500	2568	0	2180
20.PTW.21	102,7 - 121,6	18,9	Submersible	35	4320	4500	5400	3840	4542
10.PTW.22	114,5 - 132,8	18,3	Submersible	50	4320	4500	4992	6000	4179
10.PTW.23	114,5 - 132,8	18,3	Submersible	60	4320	4500	0	3840	0
10.PTW.24	121,8 - 140,1	18,3	Submersible	35	4320	4500	0	0	0
20.PTW.25	126,3 - 144,6	18,3	Submersible	35	0	0	2880	3240	2271
20.PTW.26	135,1 - 141,2	6	- ?	48,7	4320	4500	0	2880	5360
20.PTW.27	105,6 - 123,9	18	- ?	48,7	4320	4500	0	3960	5360
Total					112.320	117.000	70.901	67.060	65.357

Over the last measurements 9-11 tubewells have none to little capacity.

Some more data of MCDC's tubewells

Tube well (no.)	JICA depth screen m - surface	JICA length screen m	MCDC pump type	MCDC depth pump m - surface	MCDC design cap. m ³ /day	JICA report 2003 m ³ /day	MCDC 7-3-2014 m ³ /day	Salage m ³ /day	MCDC/VEI 9-5-2014/30-5-2014 m ³ /day
10.PTW1	128 - 146.3	18	Submersible	41.37	4320	4500	4968	6720	3634
10.PTW2	98.3 - 116.6	18	Vertical pump	35	4320	4500	5184	4560	4270
10.PTW3	123.3 - 141.6	18.3	Vertical pump	35	4320	4500	4320	3240	3543
10.PTW4	98.9 - 117.2	18.3	Vertical pump	35	4320	4500	5352	4320	4452
10.PTW5	121.4 - 140.2	19	Submersible	41.37	4320	4500	2832	3840	3725
10.PTW6	103.7 - 122	18	Submersible	35	4320	4500	4848	4080	4088
10.PTW7	128.4 - 146.7	18	Submersible	49.96	4320	4500	4728	3600	3907
10.PTW8	112.6 - 130.9	18	Submersible	44.55	4320	4500	1757	0	0
10.PTW9	107.5 - 113.6	6	Submersible	46.14	4320	4500	4656	3360	3907
10.PTW10	100.6 - 106.7	6	Vertical pump	35	4320	4500	1920	0	1454
10.PTW11	105 - 111	4	Vertical pump	35	4320	4500	4200	3840	3543
10.PTW12	123.3 - 129.4	6	Vertical pump	35	4320	4500	480	0	118
10.PTW13	111.5 - 129.8	18	Submersible	42.96	4320	4500	2928	0	0
10.PTW14	109.7 - 115.8	6	No pump installed	50.92	4320	4500	0	0	0
10.PTW15	99.7 - 105.8	6	Submersible	47.74	4320	4500	1080	0	0
20.PTW.16	90.9 - 109.2	18	Vertical pump	36.6	4320	4500	312	0	273
20.PTW.17	115.2 - 117.6	2.47	Vertical pump	35	4320	4500	0	0	0
20.PTW.18	86 - 104.3	28.3	Vertical pump	35	4320	4500	5040	5260	4179
20.PTW.19	93.8 - 106	12.2	Submersible	48	4320	4500	456	480	372
20.PTW.20	93.8 - 111.9	18.3	Submersible	35	4320	4500	2568	0	2180
20.PTW.21	102.7 - 121.6	18.9	Submersible	35	4320	4500	5400	3840	4542
10.PTW.22	114.5 - 132.8	18.3	Submersible	50	4320	4500	4992	6000	4179
10.PTW.23	114.5 - 132.8	18.3	Submersible	60	4320	4500	0	3840	0
10.PTW.24	121.8 - 140.1	18.3	Submersible	35	4320	4500	0	0	0
20.PTW.25	126.3 - 144.6	18.3	Submersible	35	0	0	2880	3240	2271
20.PTW.26	135.1 - 141.2	6	- ?	48.7	4320	4500	0	2880	5360
20.PTW.27	105.6 - 123.9	18	- ?	48.7	4320	4500	0	3960	5360
Total					112,320	117,000	70,901	67,060	65,357

At 14 tubewells the position of the pump is lowered to a level < 35m (the original level).

Some piezometric heads in MCDC's tubewells.

Tube well (no.)	depth screen m - surface	length screen m	depth pump m - surface	piezometric head m - surface	JICA report 2003 m - surface	MCDC 25-1-2005 m - surface	MCDC 1-10-2005 m - surface	MCDC 27-12-2014 m - surface	MCDC/VEI 8-3-2015/13-2-2015 m - surface
10.PTW1	128 - 146.3	18.3	41	6.40	18.29	15.40	19.30		
10.PTW2	98.3 - 116.6	18	35	7.62		15.40	19.30		14.72
10.PTW3	123.3 - 141.6	18.3	35	6.103		15.19	23.70		13.50
10.PTW4	98.9 - 117.2	18.3	35	6.89	17.00	15.40	18.10		13.20
10.PTW5	121.4 - 140.2	18.8	41			16.20	20.26	14.02	14.01
10.PTW6	103.7 - 122	18.3	35			15.40	22.76		13.95
10.PTW7	128.4 - 146.7	18.3	50	7.95	16.70	16.00	18.79		14.85
10.PTW8	112.6 - 130.9	18.3	45			16.20	20.56		15.41
10.PTW9	107.5 - 113.6	6.1	46			17.00	20.07		-
10.PTW10	100.6 - 106.7	6.1	35			16.20	17.32		-
10.PTW11	105 - 111	4	35			17.80			13.80
10.PTW12	123.3 - 129.4	6.1	35	6.20	15.20	17.10	33.30		12.89
10.PTW13	111.5 - 129.8	18.3	43				33.70		11.80
10.PTW14	109.7 - 115.8	6.1	51						11.80
10.PTW15	99.7 - 105.8	6.1	48		21.89	17.20			11.80
20.PTW.16	90.9 - 109.2	18.3	37			16.20			11.80
20.PTW.17	115.2 - 117.6	2.4	35				20.09		12.80
20.PTW.18	86 - 104.3	28.3	35				12.21		12.30
20.PTW.19	93.8 - 106	12.2	48		16.50	16.00			-
20.PTW.20	93.8 - 111.9	18.3	35						12.60
20.PTW.21	102.7 - 121.6	18.9	35						-
10.PTW.22	114.5 - 132.8	18.3	50						-
10.PTW.23	114.5 - 132.8	18.3	60						-
10.PTW.24	121.8 - 140.1	18.3	35						-
20.PTW.25	126.3 - 144.6	18.3	35		11.25		10.44		-
20.PTW.26	135.1 - 141.2	6.1	48						-
20.PTW.27	105.6 - 123.9	18.3	49						-

•Based on sparse measurements it seems the watertables in the wells have lowered 6 to 7m.



Might there be some well-clogging?

Some facts about well clogging:

- Loss of capacity.
- Well clogging undermines the reliability of the Drinkwater supply.
- Well clogging leads to waste of energy and could finally do some damage to pumps and other hardware.
- The clogging wells show an increasing draw down of the water table in the well while in operation.



What is happening in the MDCDC wells?

Some draw down figures of MDCDC's tubewells.

Tube well (no.)	depth screen m- surface	length screen m	depth pump m- surface	hydrologic report 1989 m	JICA report 2002? m- surface	MDCDC 25-1-2005 m- surface	MDCDC 1-10-2005 m- surface	MDCDC 27-12-2014 m- surface	MDCDC/VEI 8-2-2015/13-2-2014 m
10.PTW1	128 - 146,3	18,3	41	7,37					
10.PTW2	98,3 - 116,6	18	35	8,16					
10.PTW3	123,3 - 141,6	18,3	35	9,89					>25
10.PTW4	98,9 - 117,2	18,3	35	5,98					8,10
10.PTW5	121,4 - 140,2	18,8	41						>20,1
10.PTW6	103,7 - 122	18,3	35						>37
10.PTW7	128,4 - 146,7	18,3	50						>37,05
10.PTW8	112,6 - 130,9	18,3	45	5,82					28,87
10.PTW9	107,5 - 113,6	6,1	46						18,28
10.PTW10	100,6 - 106,7	6,1	35						
10.PTW11	105 - 111	4	35						
10.PTW12	123,3 - 129,4	6,1	35						
10.PTW13	111,5 - 129,8	18,3	43	0,42					
10.PTW14	109,7 - 115,8	6,1	51						
10.PTW15	99,7 - 105,8	6,1	48						
20.PTW.16	90,9 - 109,2	18,3	37						21,60
20.PTW.17	115,2 - 117,6	2,4	35						
20.PTW.18	86 - 104,3	28,3	35						
20.PTW.19	93,8 - 106	12,2	48						
20.PTW.20	93,6 - 111,9	18,3	35						
20.PTW.21	102,7 - 121,6	18,9	35						
10.PTW.22	114,5 - 132,8	18,3	50						
10.PTW.23	114,5 - 132,8	18,3	60						>38,4
10.PTW.24	121,8 - 140,1	18,3	35						
20.PTW.25	126,3 - 144,6	18,3	35						
20.PTW.26	135,1 - 141,2	6,1	49						
20.PTW.27	105,6 - 123,9	18,3	49						

- Based on sparse measurements it seems the draw down of some wells went up from approximately 6/10m to 8/>38



What is more happening at MCDC wells?

Some pictures at MCDC's tubewells.



Used pumps and parts of used pumps show none to very little deposition of Fe_2O_3 or/and $\text{Fe}(\text{OH})_2$. More substantial depositions, as an indication for well screen clogging are not present. So bore hole clogging must be the remaining cause.



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What is more happening at MCDC wells?

Some more pictures at MCDC's tubewells.



No options for well monitoring.

Some tube wells broke down and are out of operation



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Daily live at MCDC wells?



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Constraints in this assessment

- **Limited availability and accessibility of data.** Throughout the years only sparse data and information is collected and stored.
- **Measuring equipment** like flow meters **don't work properly** or are out of duty.
- Crucial information on sources, assets and processes seems to be limited available or accessible within MCDC.
- The tube well constructions are difficult, or even not accessible for groundwater monitoring. Which means **no monitoring**.
- **Studies** carried on the hydrogeological situation **show different results**.



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Conclusions

- Based on sparse data the water table seems to have dropped down with a approximately 6,5m over 25 years. In the recent 10 years the water table seems stable. Mining of the groundwater system, at an average extraction of approximately 65.000m³/day by MCDC's Ayeyarwaddy tubewells, seems to be limited.
- The number of tubewells (6-10) which are temporarily out of production because of maintenance or operational problems are limiting the production capacity of the deep tube wells.
- On the working tube wells bore hole clogging seems to be a substantial cause of the decreasing extraction capacity. (13 pumps were replaced to a lower position and 2-5 wells are pumping a mixture of air and water).
- Monitoring, maintenance and data management is a point of focus.



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Thank you for your attention

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