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Characteristics Of The Hot Thermal Mineral Water Source And Capability To Exploite For Usesing To Service Ecological Tourism

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Abstract

The hot Thermal mineral water source of Xuan Dam, Cat Ba, Hai Phong has good quality, abundant reserves, so it has good value for refreshment and bathing, relaxation and eco-tourism. Mineral water exists in Carbon-Pecmian aged limestone sediments (C_3-P) at a depth of 48m to 120m and is related to tectonic faults. The research results show that mineral water is distributed in a narrow form, stretching in the Northwest-Southeast direction, coinciding with the tectonic fault development. In the borehole CB29, hot thermal mineral water was discovered and distributed in the Quaternary deposits located in the middle of Goi stream.

Mineral water is characterized by mineralization (M>2g/l) and temperature (36^{o}C). Water is a kind of high mineralization, hot water, type of chloride-bicarbonate, sodium. The result of determining mineral reserve in CB29 borehole is: level B is 518m^3/day and C_1 reserve is 288.5m^3/day.

Due to the good quality, abundant reserves, located right on the island, close to the famous bathing area, Xuan Dam, Cat Ba that thermal mineral water is of high value, can be bottled and refreshed and develop eco-tourism.

Key word: hot thermal mineral water, Xuan Dam, Cat Ba, exploited and used

1. Set the scene

Xuan Dam hot mineral water source is located in Xuan Dam commune, Cat Hai district, on the scope of Cat Ba island in northeastern Vietnam. Cat Ba is an island with mainly limestone terrain, creating an extremely attractive and poetic landscape and a long-standing famous tourist destination. Therefore, clarifying the characteristics of quality and reserves of mineral water for bottling, drinking and soaking in tourist resorts is particularly important. Hot mineral water source will be the driving force and tourist attraction for the island. The area of mineral water distribution is shown in Figure 1.

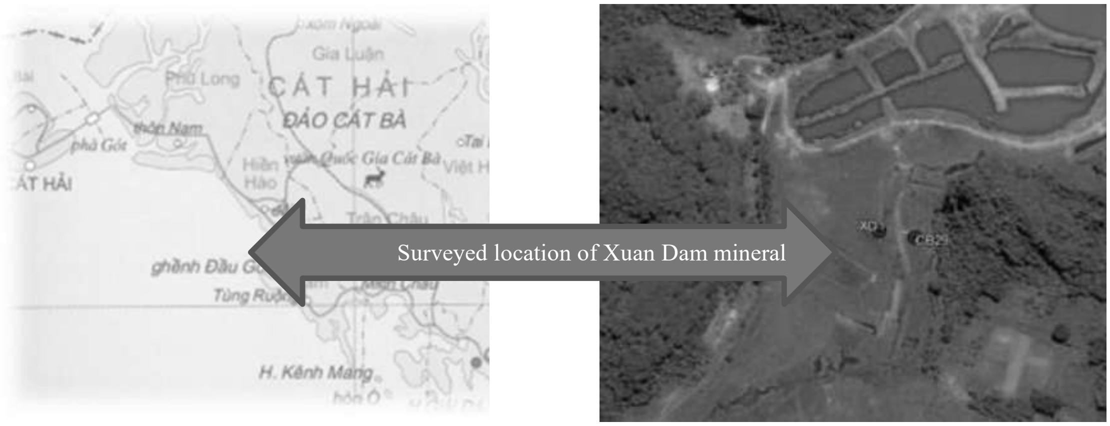

Figure 1. Surveyed area

2. Research method

In order to assess the quality and reserves of mineral water used for rational exploitation according to the aims given, we have applied the following research methods:

- Methods of collecting documents.
- Method of field survey, sampling analysis.
- Method of Geophysical measurements.
- Method of exploration drilling and exploitation drilling
- Method of pumping test
- Method of geodetic
- Method of adjusting and writing research results.

3.Results and discussion

3.1. Assessing the quality of mineral water

For hot mineral water, the study of water quality and assessment is extremely important, requiring the assessment to be systematic and rigorous. Quality of mineral water is the basis for us to orient the exploitation as well as to use this precious resource in a scientific way, bringing much efficiency in economic life and protecting this precious water source.

For the purpose of using mineral water for bottling, refreshing and bathing, tourist resort, we base on the results of analysis of mineral water samples and current regulations of the state to assess. Samples were analyzed at the prestigious laboratories which can be named such as Geological Environmental Research Center; Laboratory of Microbiology, Laboratory of Chemistry - Environment under the General Department of Standards and Quality Quatest 1, Institute of Environmental Technology under Vietnam Academy of Science and Technology. The total number of samples taken was 64 samples [1]. Samples are taken in accordance with professional regulations and sent to the laboratories meeting the standards mentioned above.

3.2. Quality assessment according to mineral water identification criteria

In order to identify Xuan Dam mineral water, we compare the results of sample analysis with the regulation according to Circular 52/2014 / Ministry of Resources and Environment. Results of sample analysis and mineral water identification in borehole CB29 are shown in Table 1 below.

Table 1. Results of assessment and identification of mineral water Xuan Dam, Cat Ba

(According to TT52 / 2014- Ministry of Resources and Environment)

o.	**Targets**	**U nit**	**Con tent mi nimum**	**Analysis results** (Min-Max) (Average)	**Assess ment**
	Mineralization (for water with no specific elements)	m g/l	< 50 ≥ 50 - 500 > 500-15000 > 1500	2120-2480 2250	Meet standard of high mineralization water
	Free carbon dioxide (soluble)	m g/l	500	128-150 140	Not Meet standard of high mineralization water
	Total hydrogen sulfide (H_2S + HS)	m g/l	1	<0,05	Not Meet standard of high mineralization water
	Fluor	m g/l	2	0,44-0,57 0,52	Not Meet standard of high

					mineralization water
	Total iron (Fe^{2+} + Fe^{3+})	mg/l	10	0,04-0,3 0,09	Not Meet standard of high mineralization water
	Arsenic	mg/l	0,7	<0,001	Not Meet standard of high mineralization water
	Brom	mg/l	5	<0,1	Not Meet standard of high mineralization water
	Iodua	mg/l	1	<0,05	Not Meet standard of high mineralization water
	Acid metasilic (H_2SiO_3) Methasilic acid	mg/l	50	6,2-9,5 6,9	Not Meet standard of high mineralization water
0	Axit metaboric (HBO_2) Metaboric acid	mg/l	5	-	-
1	Radium	pCi/l	10	-	-
	Temperature	ºC	30	36	Meet

2	(for water without specific elements)				standard of high mineralization water

Thus, hot mineral water in Xuân Dam has 2 specific components: mineralization (> 2g / l) and temperature (36ºC). The content of solutes and temperature are always stable over time. Xuan Dam mineral water is identified as "high mineralization, hot water, type of chloride - sodium bicarbonate".

3.3. Assessing the quality of mineral water according to drinking water standards

Assessment of the quality of drinking mineral water is based on "National technical regulation on drinking water quality" QCVN 6-1: 2010/BYT.

From the analysis results of Xuan Dam mineral water samples compared to the current standard, it is found that mineral water is of good quality, most of the criteria are ensured for eating and drinking. The content of substances that can form deposits like H_2SiO_3 is quite small. The content of trace elements in all samples is below the permissible limit. Summary of sample analysis results and comparison with standards is shown in Table 2.

Table 2. Evaluation of mineral water quality according to drinking water standards [1]

o.	Targets	nit	Analysis results			QC VN 6-1: 2010/BYT	Ass essment
			M in	M ax	A verage		
	Cadimi content (Cd)	g/l	0 .0001	0 .0001	0 .0001	0,0 03	Me et standard
	Chromium content (Cr-)	g/l	< 0.05	< 0.05	< 0.05	0,0 5	Me et standard
	Copper content (Cu)	g/l	0 .001	0 .0025	0 .0020	1	Me et standard
	Cyanid content (CN^-)	g/l	K PH	K PH	K PH	0,0 7	Me et standard
	Lead content (Pb)	g/l	0 .001	0 .001	0 .001	0,0 1	Me et standard
	Mercury content (Hg)	g/l	< 0.0001	< 0.0001	< 0.0001	0,0 01	Me

o.	Targets	nit	Analysis results			QCVN 6-1: 2010/BYT	Assessment
			Min	Max	Average		
							et standard
	Nickel content (Ni)	g/l	0.001	0.003	0.001	0,02	Meet standard
	Fluoride content (F-)	g/l	0.52	0.64	0.60	_ 2)	Meet standard
	Arsenic content (As)	g/l	< 0.001	< 0.001	< 0.001	0,01	Meet standard
0	*NO_2^- Content*	g/l	KPH	KPH	KPH	0,1	Meet standard
1	*NO_3^- Content*	g/l	< 0.1	< 0.1	< 0.1	50	Meet standard
2	*Coliforms*	PN/ 100ml	KPH	KPH	KPH	KPH	Meet standard
3	*E.Coli*	PN/ 100ml	0	0	0	KPH	Meet standard
4	*Total aerobic bacteria*	CFU/ ml)	0	0	0	-	Meet standard
5	*Surfactants*	g/l	< 0.001	< 0.001	< 0.001	-	Meet standard
6	*Residues of plant protection drugs and PCBs (polycarbonates biphenyl)*	g/l	KPH	KPH	KPH	-	Meet standard
7	*Mineral oil*	g/l	(<0.01)	(<0.01)	(<0.01)	-	Meet standard
8	*Polycyclic aromatic hydrocarbons*	g/l	KPH (<0.01)	KPH (<0.01)	KPH (<0.01)	-	Meet standard

o.	Targets	nit	Analysis results			QC VN 6-1: 2010/BYT	Ass essment
			M in	M ax	A verage		
9	Radioactivity a	q/l	0 .0031	0 .0044	0 .0037	-	-
0	Radioactivity b	q/l	0 .019	0 .026	0 .023	-	-

Table 2 shows that the quality of Xuan Dam mineral water source is very good, ensuring the requirements for drinking water. The composition of solutes is quite stable in the samples analyzed and stable over time.

The content of radioactive substances is very small, only reaching the billionth of mg / l, meeting the requirements for drinking water and bathing water, soaking for relaxation [1; 6], see table 3.

Table 3. Results of measurement of Radon and Radium content in Xuan Dam mineral water.

o.	Names of targets	Unit	Re sult	Asse ssment
	Radon concentration (M1)	Bq/l	0,1 38	Meet standard
	Radium concentration (M1)	mg/l	1,9 4.10^{-9}	Meet standard
	Radon concentration (M2)	Bq/l	0,1 41	Meet standard
	Radium concentration (M2)	mg/l	1,7 8.10^{-9}	Meet standard

3.4. Assessing the quality of mineral water according to bathing and soaking for relaxation standards

The assessment results show that composition of solutes and temperature of mineral water are very suitable for bathing and soaking for relaxation, especially with relatively high TDS content (> 2 g/l) and temperature (36°C) so it is good for soaking for relaxation, see table 4.

Table 4. Components of Xuan Dam water mineral good for soaking for relaxation [1]

No.	Names of targets	Unit	Analysis Result (Min-Max) (Average)	
			CB29 (năm 2015)	CB29 (năm 2016)
1	TDS	mg/l	2143-2182 2160	2120-2480 2250
2	CO_2	mg/l	139-149 144	128-150 140
3	Temperature	^oC	36	36

3.5. Calculation of mineral water reserves

In order to ensure reliability when calculating mineral water reserves, we apply hydraulic method, based on experimental pumping test data to calculate. Hydraulic method gives good results when there is pumping test material with 3 times lowering water level and exploitation pumping test. In the course of the study, we have done long-term water pumping tests, which is quite sufficient to assess reserves.

- Determine the hydrogeological parameters of mineral water mines

The hydrogeological parameters were determined by Jacob's Theis formula by time tracking method.

With documents of pumping test: $S = \frac{0,183Q}{km} \lg \frac{2,25a}{r^2} + \frac{0,183Q}{km} \lg t$

With documents of rising the water level: $S^* = \frac{0,183Q}{km} \lg \frac{T+t}{t}$,

The formula for calculating the permeability coefficient of the aquifer is: $Km = \frac{0,183Q}{C_t}$

In which:

Q - Water suction flow of experimental boreholes (m^3 / day);

Ct - Slope ratio of S - lg graph (t / T + t);

A_t - The straight line in which the graph cuts the corresponding vertical axis;

r - Radius of drill holes; Km - Water conductivity coefficient (m^2 / ng);

*a - Water transmission coefficient (m2 / ng); S * - Elevating the water level (m)*

From the data of experimental pumping test, measuring water level recovery, draw graphs showing S-lgt relationship; S-lg (t / T + t).

From the graphs showing the relationship between S and lgt, select the hydrogeological parameter calculation, see figures 2 and 3 below.

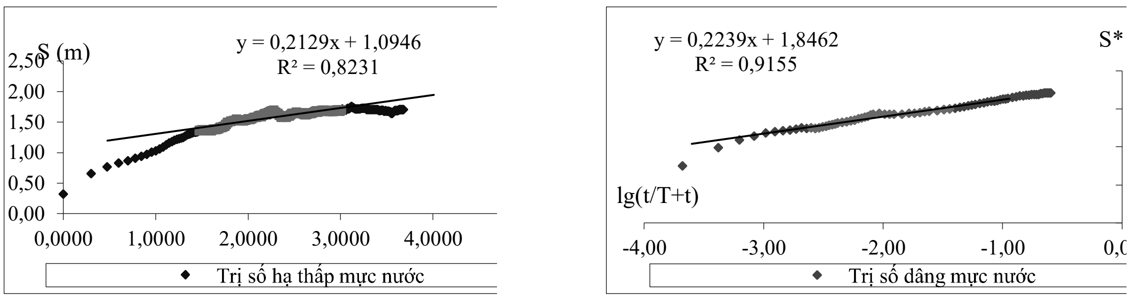

*Figure 2. Graph showing the relationship between S-lgt and S * -lgt / T + t experimental pumping test in CB29 [1]*

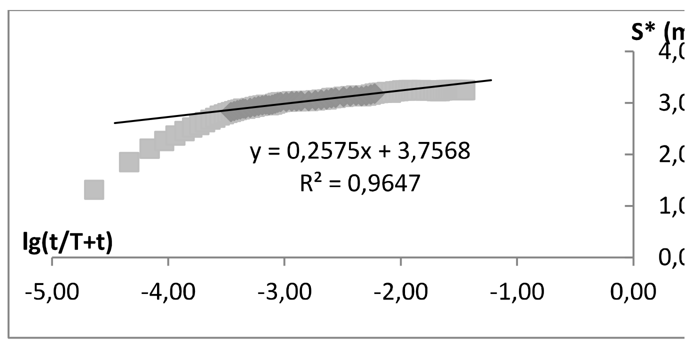

*Figure 3. Graph showing the relationship between S * - lg (t / T + t) when exploitation pumping test at the hole of CB29*

From materials of pumping test and graphs, calculating of the water conductivity coefficient is shown in Table 4 below.

Table 4. Results of parameter calculation according to experimental documents

Borehole number	**Numbers of pumping**	**Relationship equation**	**R^2**	**Km (m^2/day)**
CB29	Pumping test 1	y = 0,2129x + 1,0946	0,8231	222,80
	Pumping test 2	y = 0,4177x +	0,	2

Bo rehole number	Numbers of pumping	Relationship equation	R^2	Km (m^2/day)
		1,6137	9867	30,84
	Pumping test lần 3	y = 0,5442x + 2,9136	0, 8664	2 61,49
	Exploitation Pumping test	y = 0,4706x + 1,8154	0, 9518	2 01,59
	Measuring water level recovery 1	y = 0,2239x + 1,8462	0, 9155	2 11,85
	Measuring water level recovery 2	y = 0,3492x + 3,4131	0, 9000	2 71,67
	Measuring water level recovery 3	y = 0,4538x + 5,2563	0, 9268	2 43,89
	Measuring water level recovery of exploitation pumping test	y = 0,2575x + 3,7568	0,9647	2 50,18
	Average			***2 36,79***

From the results of calculating parameters we have some comments:

- The correlation between time and drawdown (or rising value) is very tight (R^2> 0.82 when determining S and R^2> 0.9 when determining S *).

- The results of calculating parameters according to the documents of pumping tests are relatively stable through the times of pumping tests.

- The difference in value between calculating according to pumping tests and recovery in each borehole and overall for the all the pumping tests is not large. That shows that the result of pumping test is reliable to assess reserves. Selecting the value of water drainage coefficient is the average value of the periods of pumping tests and exploitation tests, equal to 236.79 m^2 / day.

- Evaluation of mineral water exploitation reserves

Exploitation reserves are guaranteed when the lowering value when exploiting (Skt) is smaller than the allowed lowering water level value. At CB29: S = 0.4706 lgt + 1.8154 After 27 years, the value of lowering the water level at the borehole CB29 is: 4.34m, smaller than the allowed lowering value of 12.80m. Therefore, reserves of exploitation are guaranteed. From documents of pumping tests of 3 times lowering our water level, we can set up Table 5.

Table 5: Synthesis of results of single pumping test with 3 times of lowering water level

Number of boreholes	**LHL**	**S (m)**	**Q (l/s)**	**S_0=S /Q**	**lgQ**	**lgS**
CB29	1	1,71	3,00	0,57	0,48	0,23
	2	3,02	6,00	0,50	0,78	0,48
	3	4,90	9,00	0,54	0,95	0,69

The relationship between flow and water level lowering values follows Smoreke's relationship (lgQ = a + blgS), according to the equation: lgQ = 1.0486 * lgS + 0.246 and Skt = 3.23 x 1.75 = 5, 65m. Since then, we can identify the reserves of all levels in CB29.

- Decentralizing exploitation reserves

+ Reserve level B: is equal to the total long-term exploited reserve in borehole CB29, determined as Q = 6.0 l / s or 518m3 / ng

+ Reserve level C1: Calculated according to the extrapolation flow [1; 4; 5] from documents of pumping test and documents of exploitation pumping test in CB29. The result of calculating C1 reserve at CB29 borehole is 288.57 m^3 / day.

3.6. Orientation of exploiting hot mineral water Xuan Dam, Cat Ba

- Because hot mineral water is of good quality, reserves are abundant, so it needs to be exploited and used for socio-economic development. In particular, prioritize the exploitation of this resource for drinking, refreshing and serving bath and relaxation. The components M> 2g / l and T = 36^{o}C are two important factors that are significant for both of these uses, especially important for Cat Ba tourist island.

- When exploiting, it must comply with professional regulations and management to protect this precious mineral water source. Specifically, it is not allowed to exploit when the water level exceeds the lower value allowed. At the same time, to build protection zones according to regulations of management levels.

4. Conclusion

4.1. Xuan Dam hot mineral water source, Cat Ba island, Cat Hai district, Hai Phong city is a very valuable resource. Good quality and abundant reserves should be exploited and used for socio-economic development.

4.2. Since the composition of solutes ensures quality for eating and drinking, other soluble ingredients are beneficial for bathing, relaxing, so Xuan Dam mineral water can be used for many purposes, bringing economic and social benefits.

4.3 Hot mineral water source is distributed in zone of C_3-P limestone [2; 5; 6] and has a deep geothermal origin, so it should be protected for long-term exploitation.

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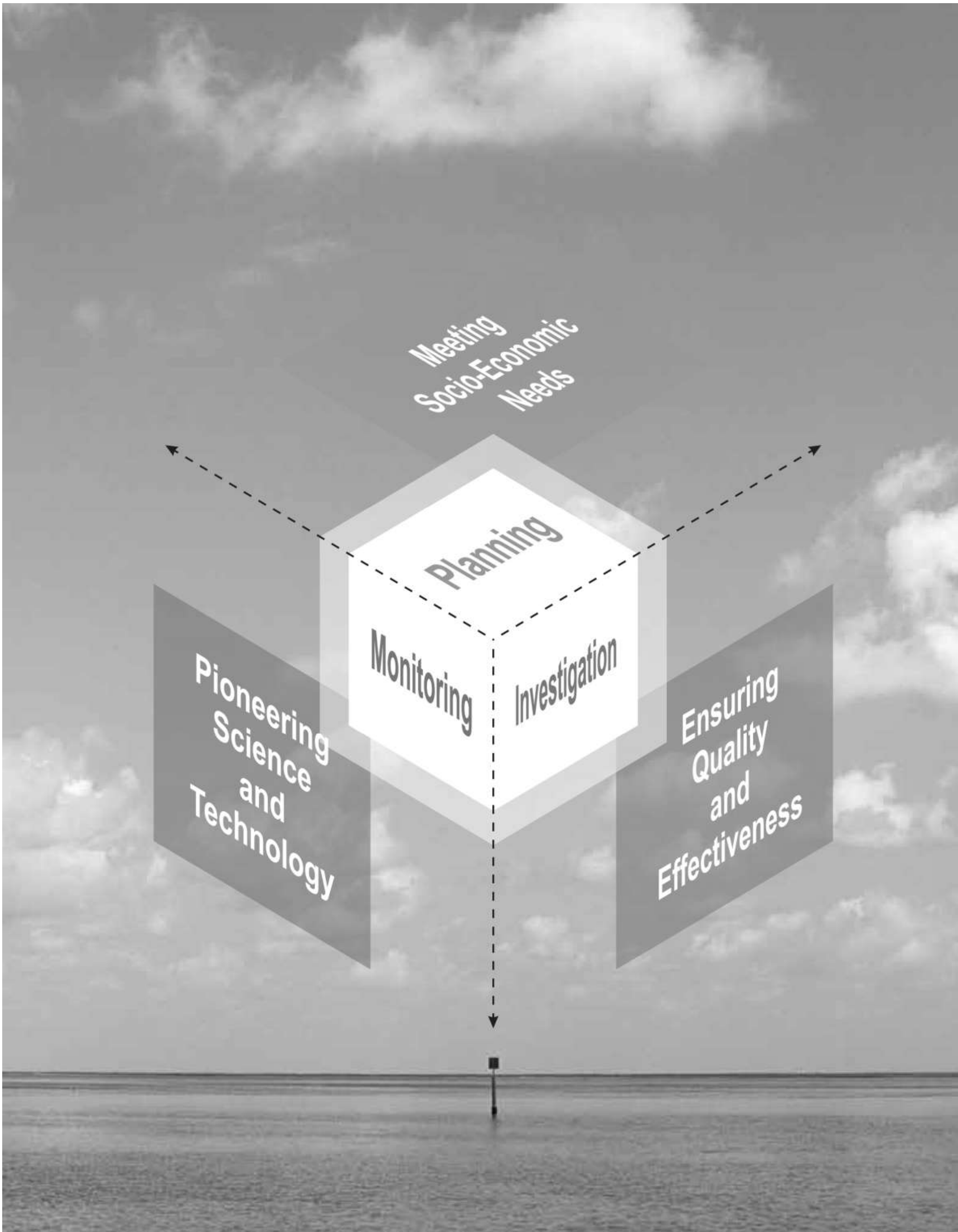

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