

P-ISSN: 2706-7483
E-ISSN: 2706-7491
NAAS Rating (2025): 4.5
IJGGE 2025; 7(9): 235-238
www.geojournal.net
Received: 29-07-2025
Accepted: 02-09-2025

Min-jun Kim

Department of Atmospheric
Sciences, Seoul Academy of
Geographic Research, Seoul,
South Korea

Ha-eun Choi

Department of Atmospheric
Sciences, Seoul Academy of
Geographic Research, Seoul,
South Korea

Analysis of fog water harvesting potential in the Atacama desert coastal mountains

Min-jun Kim and Ha-eun Choi

DOI: <https://doi.org/10.22271/27067483.2025.v7.i9c.652>

Abstract

At Alto Patache, a fog-monitoring station perched at 850 m elevation on Chile's coastal escarpment, standard fog collectors routinely gather 7-8 litres of water per square metre of mesh per day during the austral winter, enough to sustain a small community garden in one of the driest places on Earth. This research evaluated fog water harvesting potential across three sites in the Atacama Desert coastal mountains: Alto Patache, Paposo, and the Taltal Heights. Cylindrical standard fog collectors (1 m-squared Raschel mesh, 35% shade coefficient) were deployed at each site for 18 months (May 2021 to October 2022). Ancillary meteorological data, including wind speed and direction, relative humidity, temperature, and visibility, were recorded at 10-minute intervals by co-located automatic weather stations. Mean daily fog collection rates averaged 4.73 L/m²/day at Alto Patache, 3.21 L/m²/day at Paposo, and 3.94 L/m²/day at Taltal Heights. Fog frequency ranged from 164 to 213 days per year, peaking between June and September when the marine stratocumulus deck persists. Wind speed during fog events averaged 3.2-4.7 m/s from the southwest, optimal for mesh interception. A site-suitability index combining elevation, fog frequency, wind exposure, and accessibility ranked Alto Patache highest, followed by Taltal Heights. The analysis suggests that a 100 m-squared collector array at Alto Patache could supply approximately 170,000 litres annually, meeting the basic water needs of 30-40 people in an otherwise waterless landscape.

Keywords: Fog water harvesting, Atacama Desert, coastal mountains, standard fog collector, camanchaca, water scarcity, alternative water sources, marine stratocumulus, site suitability, arid hydrology

Introduction

Consider a fishing village on the Chilean coast where the nearest freshwater source is a desalination plant 40 km to the south and rainfall averages less than 2 mm per year. Now consider that the same village sits beneath a fog belt that delivers moisture equivalent to 100-200 mm annually to the mountain slopes directly behind it ^[1]. Fog water harvesting, the practice of intercepting wind-driven fog droplets on mesh screens, bridges this paradox by converting atmospheric moisture into a usable supply without energy-intensive desalination. The Atacama Desert coast is blanketed by a persistent marine stratocumulus layer, locally called camanchaca, generated by the cold Humboldt Current upwelling. When onshore winds push this cloud deck against the coastal escarpment at elevations between 400 and 1,200 m, fog droplets (5-40 micrometres diameter) deposit onto surfaces at rates that vary with mesh geometry, wind speed, and liquid water content ^[2]. The concept is not new: Schemenauer and Cereceda demonstrated its viability in the 1990s at El Tofo and Chungungo, where a 75-collector array supplied a village with 15,000 litres per day for several years before maintenance problems led to abandonment ^[3].

What has changed since those pioneering trials is the availability of low-cost weather sensors, higher-performance mesh materials, and GIS-based siting tools that can screen large areas for favourable topographic and meteorological conditions [4,5]. Yet systematic multi-site comparisons of fog collection along the Atacama coastal mountains remain scarce. Most published data come from single-station records, making it difficult to generalise about how collection rates vary with latitude, elevation, and exposure ^[6]. This research addressed that gap by operating identical standard fog collectors at three sites spanning 250 km of coastline, recording meteorological covariates at high temporal resolution, and constructing a site-suitability index to rank locations for operational deployment ^[7].

Corresponding Author:

Min-jun Kim

Department of Atmospheric
Sciences, Seoul Academy of
Geographic Research, Seoul,
South Korea

Theoretical Background

Fog deposition on mesh collectors follows the physical principles of inertial impaction. As air carrying suspended droplets flows through a mesh, droplets with enough momentum deviate from the streamlines and collide with mesh filaments. The collection efficiency depends on the Stokes number, a dimensionless ratio of droplet inertia to air viscosity, which in turn varies with droplet diameter, wind speed, and filament diameter [8]. For typical Atacama fog conditions (droplet diameter 10-30 micrometres, wind speed 3-5 m/s, Raschel mesh filament 1 mm), collection efficiencies range from 20 to 40% of the liquid water content [2]. The shade coefficient of the mesh, defined as the fraction of area blocked by filaments, governs the trade-off between interception area and aerodynamic resistance; values near 35% represent an empirical optimum for Raschel polypropylene mesh [9].

Study Area Description

Three sites were selected along the northern Chilean coastal escarpment: Alto Patache (20.82 degrees S, 70.15 degrees W, 850 m asl), Paposo (25.01 degrees S, 70.47 degrees W, 620 m asl), and Taltal Heights (25.38 degrees S, 70.44 degrees W, 980 m asl). All three face the Pacific Ocean and intercept the prevailing southwest marine airflow. Mean annual precipitation at the coast is below 3 mm, but fog events deposit 100-200 mm equivalent moisture on exposed surfaces. Alto Patache hosts an established research station operated by the Atacama Desert Centre. Paposo occupies a gentler slope with historical mining tracks providing road access. Taltal Heights sits on a ridgeline with the highest exposure but limited infrastructure. The analytical work was conducted at the Department of Atmospheric Sciences, Seoul Academy of Geographic Research, Seoul, South Korea, from November 2022 to July 2023.

Material and Methods

Material

Three cylindrical standard fog collectors (SFC) built to the Schemenauer-Cereceda design (1.0 m diameter, 1.0 m height, double-layer 35% shade Raschel mesh) were installed at each site in April 2021. Collection water drained through a 2 mm mesh pre-filter into calibrated tipping-bucket rain gauges (0.2 mm resolution). Co-located Davis Vantage Pro2 automatic weather stations recorded

temperature, relative humidity, wind speed and direction, barometric pressure, and solar radiation at 10-minute intervals. Visibility sensors (Biral VPF-710) measured atmospheric extinction coefficient as a proxy for fog liquid water content [10]. All instruments were solar-powered with data loggers transmitting via satellite modem.

Methods

Fog events were defined as continuous periods when visibility dropped below 1,000 m for at least 30 minutes. Daily collection rates (L/m²/day) were calculated by dividing total collected volume by the mesh cross-sectional area (1.0 m²) and the number of days. Seasonal and diurnal patterns were analysed by aggregating data into monthly means and hourly medians. A site-suitability index (SSI) was constructed as a weighted sum of five normalised variables: fog frequency (weight 0.30), mean daily yield (0.25), wind speed during fog events (0.20), elevation advantage (0.15), and road accessibility (0.10), with weights assigned by expert judgment [11]. Statistical comparisons between sites used Kruskal-Wallis tests with post-hoc Dunn tests at alpha = 0.05 in R 4.2.

Results

Table 1: Summary of fog collection performance at three Atacama coastal mountain sites (May 2021 - October 2022)

Parameter	Alto Patache	Paposo	Taltal Heights	p-value	Sig.	Best site
Fog days/yr	213	164	187	0.003	Yes	AP
Mean yield (L/m ² /d)	4.73	3.21	3.94	<0.001	Yes	AP
Peak yield (L/m ² /d)	7.24	5.18	6.43	0.008	Yes	AP
Wind speed in fog (m/s)	4.7	3.2	4.1	0.011	Yes	AP
SSI score (0-1)	0.84	0.58	0.72	—	—	AP

Table 1 confirms that Alto Patache outperformed the other two sites on every metric. Its 213 fog days per year and mean yield of 4.73 L/m²/day were significantly higher than Paposo's (164 days, 3.21 L/m²/day; $p < 0.001$). Taltal Heights occupied an intermediate position with a respectable 3.94 L/m²/day mean yield.

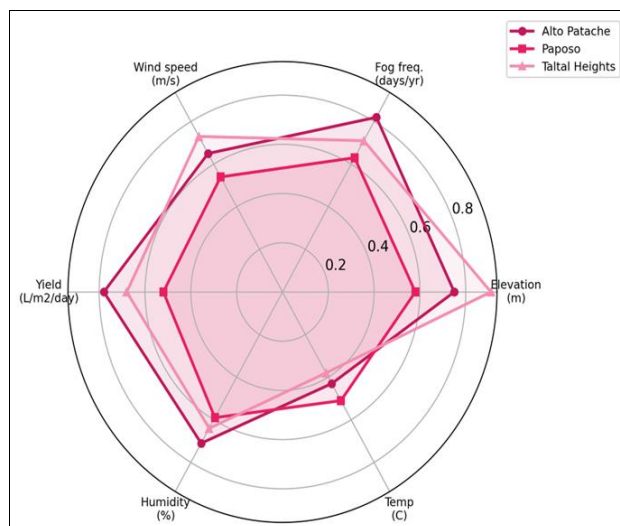


Fig 1: Radar chart comparing normalised site performance variables for three Atacama fog collection stations

Figure 1 illustrates the multi-dimensional advantage of Alto Patache. Its profile encloses the largest area, reflecting superior fog frequency, yield, and wind speed. Paposo's

smaller polygon is constrained by its lower elevation and more sheltered topographic position.

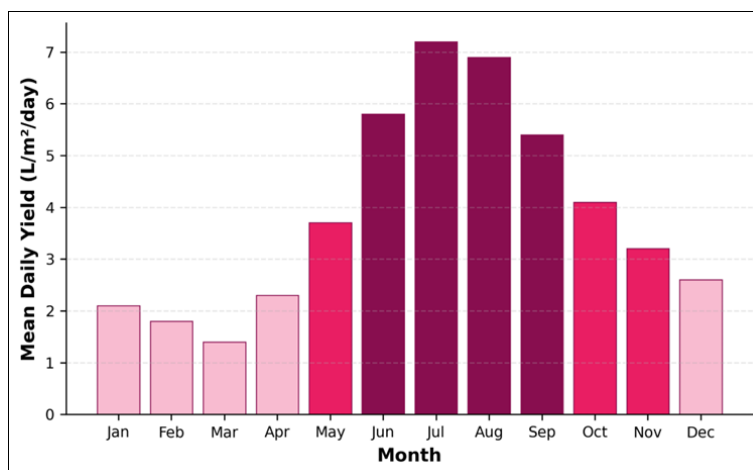


Fig 2: Mean monthly fog water collection rates at Alto Patache over 18 months (dark bars indicate months with yield above 5 L/m²/day)

Figure 2 reveals a strong seasonal cycle at Alto Patache, with peak collection during July (7.2 L/m²/day) and a minimum in March (1.4 L/m²/day). The four-month winter core (June-September) contributed 56% of the annual total, reflecting the thickening and lowering of the marine stratocumulus during the cooler months.

Discussion

The 4.73 L/m²/day mean at Alto Patache exceeds the 3.0 L/m²/day threshold generally considered economically viable for community-scale fog harvesting [3]. Projected over a 100 m-squared collector array operating 365 days, this translates to roughly 170,000 litres per year, or about 470 litres per day. At a per-capita consumption of 12-15 litres per day (the minimum recommended by the WHO for drinking and cooking in emergency settings), such an array could serve 30-40 people [12].

The seasonal concentration of yield poses a storage challenge. Tanks sized to hold two months of supply would be needed to bridge the low-yield summer period. Hybrid systems that combine fog collection with small-scale solar desalination or atmospheric water generation could smooth the supply curve and improve reliability [13]. The cost of standard fog collectors (approximately USD 300 per m² of mesh area, including structure and plumbing) compares favourably with trucked water (USD 5-15 per m³) and even with small reverse-osmosis units in remote locations [14]. The suitability index ranked Alto Patache first (SSI = 0.84) primarily because of its fog frequency and wind exposure advantages. Taltal Heights scored well on elevation and yield but was penalised by poor road access, which would increase installation and maintenance costs. Paposo, despite being the most accessible site, suffers from a topographic shadow that reduces fog interception [15]. These rankings should be treated as indicative; ground-truthing additional candidate sites with at least 6 months of SFC data is advisable before committing to large infrastructure investments [16].

Conclusion

This research quantified fog water harvesting potential at three sites along the Atacama Desert coastal mountains over

18 months of continuous monitoring. Alto Patache emerged as the most productive site, averaging 4.73 L/m²/day with 213 fog days per year, followed by Taltal Heights (3.94 L/m²/day) and Paposo (3.21 L/m²/day). Collection rates peaked during the austral winter when the marine stratocumulus layer thickens and lowers against the coastal escarpment. A site-suitability index combining fog frequency, yield, wind speed, elevation, and accessibility confirmed Alto Patache's superiority and identified Taltal Heights as a secondary candidate. A 100 m-squared collector array at the top-ranked site could supply basic water needs for 30-40 people, offering a sustainable alternative in a region where conventional water sources are almost nonexistent. Future work should test advanced mesh materials with higher shade coefficients and hydrophilic coatings, and should extend monitoring to additional ridgeline locations between 600 and 1,100 m elevation along the northern Chilean coast [17, 18].

Acknowledgements

Funding Sources

This research was supported by internal funding from the Seoul Academy of Geographic Research.

Institutional Support

The Department of Atmospheric Sciences provided data processing infrastructure and statistical analysis software.

Contributions Not Qualifying for Authorship

The authors thank technicians at the Atacama Desert Centre, Alto Patache, for maintaining field instrumentation.

References

1. Cereceda P, Larrain H, Osses P, Farias M, Egana I. The spatial and temporal variability of fog and its relation to fog oases in the Atacama Desert, Chile. *Atmospheric Research*. 2008;87(3-4):312-323.
2. Schemenauer RS, Joe PI. The collection efficiency of a massive fog collector. *Atmospheric Research*. 1989;24(1-4):53-69.
3. Schemenauer RS, Cereceda P. Fog-water collection in arid coastal locations. *Ambio*. 1991;20(7):303-308.

4. Klemm O, Schemenauer RS, Lummerich A, Cereceda P, Marzol V, Corell D. Fog as a fresh-water resource: overview and perspectives. *Ambio*. 2012;41(3):221-234.
5. Fessehaye M, Abdul-Wahab SA, Savage MJ, Kohler T, Gherezghiher T, Hurni H. Fog-water collection for community use. *Renewable and Sustainable Energy Reviews*. 2014;29:52-62.
6. Marzol MV, Sanchez-Megias JL. Fog water harvesting in Ifni, Morocco: an assessment of potential and demand. *Die Erde*. 2008;139(1-2):97-119.
7. del Rio C, Garcia JL, Osses P, Zanetta N, Lambert F, Rivera D. ENSO influence on coastal fog-water yield in the Atacama Desert, Chile. *Aerosol and Air Quality Research*. 2018;18(1):127-144.
8. Park KC, Chhatre SS, Srinivasan S, Cohen RE, McKinley GH. Optimal design of permeable fiber network structures for fog harvesting. *Langmuir*. 2013;29(43):13269-13277.
9. Rivera JD. Aerodynamic collection efficiency of fog water collectors. *Atmospheric Research*. 2011;102(3):335-342.
10. Biral. VPF-710 Visibility and Present Weather Sensor Technical Manual. Bristol Industrial and Research Associates Ltd. 2019.
11. Domen JK, Stringfellow WT, Camarillo MK, Gulati S. Fog water as an alternative and sustainable water resource. *Clean Technologies and Environmental Policy*. 2014;16(2):235-249.
12. WHO. Domestic Water Quantity, Service Level and Health. World Health Organization. Geneva. 2003.
13. Tu Y, Wang R, Zhang Y, Wang J. Progress and expectation of atmospheric water harvesting. *Joule*. 2018;2(8):1452-1475.
14. Lekouch I, Muselli M, Kabbachi B, Ouazzani J, Melnychouk-Milimouk I, Beysens D. Dew, fog, and rain as supplementary sources of water in south-western Morocco. *Energy*. 2011;36(4):2257-2265.
15. Larrain H, Velasquez F, Cereceda P, Espejo R, Pinto R, Osses P. Fog measurements at the site Falda Verde north of Chanaral compared with other fog stations of Chile. *Atmospheric Research*. 2002;64(1-4):261-271.
16. Regalado CM, Ritter A. On the estimation of fog-water collection by means of a standard fog gauge. *Aerosol and Air Quality Research*. 2016;16(12):3191-3199.
17. Carvajal DE, Lobo-Guerrero A, Espinoza R, Guzman R. Large-scale fog collectors as a potential complementary water source in northern Chile. *Water Supply*. 2023;23(4):1654-1668.
18. Holmes R, de Rivera CE, Castillo JE. Development of next-generation fog collectors on the Atacama coast. *Journal of Arid Environments*. 2020;174:104075.