

ARTIFICIAL WATER SITES – GOOD PRACTICE OR TRAP FOR AMPHIBIANS: A CASE STUDY FROM BANJANI AND GOLIIJA (NIKŠIĆ, MONTENEGRO)

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Abstract

Artificial water sites (AWSs) are being increasingly constructed in the karst regions of Banjani and Golija (Montenegro) to support livestock farming and alleviate water scarcity. This study assessed their importance for amphibians and evaluated potential negative effects on wildlife. Field surveys conducted between April and July 2025 covered 19 AWSs, where seven amphibian species were recorded. The most widespread species was *Bufo bufo*, present in 13 reservoirs. Amphibians were not recorded in the only two surveyed water bodies where fish had been introduced. Despite their value as breeding habitats, several AWSs contained dead or trapped amphibians, particularly *Bufo bufo*, due to steep walls and smooth waterproof linings that prevented animals from escaping. Similar problems were observed in other vertebrates, including *Natrix natrix* and *Erinaceus roumanicus*. These findings suggest that AWSs can function both as important surrogate habitats and as ecological traps. Incorporating wildlife-friendly features such as escape ramps and textured surfaces would significantly improve their conservation value. The study highlights the need to integrate biodiversity considerations into the planning and management of rural water infrastructure in Montenegro.

Key words: amphibians, AWS, ecological trap, karst landscape, conservation, Montenegro

INTRODUCTION

The Banjani region, located in north-western Montenegro and administratively part of the Nikšić municipality, covers an area of approximately 370–380 km². It is bordered by the Njegoš, Somina, Bratogošta, and Oputne Rudine mountains, as well as the Gradina, Vardar, Golo Brdo, and Zaljuta hills. The elevation ranges from about 400 meters in the village of Petrovići (Lower Banjani) to over 1.700 meters at the peak of Ravna Glavica on Mount Njegoš (Milović, 2023).

The Golija region is also located in north-western Montenegro and administratively part of the Nikšić municipality, borders the region of Banjani and covers an area of approximately

200 km². It is bordered by the Njegoš and Somina mountains on west and Piva mountain on north. The highest peak is Mlečeve Grede, reaching 1.942 meters above sea level.

Both regions are a typical karst landscape dominated by limestone and dolomite formations, with minimal arable land and a pronounced scarcity of surface water. Only a few springs exist in the area (especially in Banjani), which poses a considerable challenge for both human livelihoods and ecological sustainability (Tadić, 2019). Despite these limitations, Banjani and Golija has long been known for extensive livestock farming, which remains a key economic activity in the region.

In response to water scarcity, the Ministry of Agriculture, Forestry and Water Management of Montenegro regularly supports the construction of artificial water sites (AWSs) through rural infrastructure investment programs. These initiatives are not only vital for agricultural development but also present an opportunity for biodiversity conservation. Amphibians, in particular, may benefit from such interventions. As integral components of food webs, amphibians help control invertebrate populations and serve as prey for numerous predators (Vitt and Caldwell, 2013). However, they are highly sensitive to environmental changes, with habitat loss being one of the primary drivers of their global decline. AWSs can serve as surrogate habitats, offering suitable breeding and foraging sites in otherwise inhospitable landscapes. As such, several studies underscore their potential role in amphibian conservation (Bellakhal *et al.*, 2014; Caballero-Díaz *et al.*, 2020, 2022; Romano, 2025).

In the Banjani and Golija regions, AWSs represent simple engineering structures primarily designed for water storage in agricultural contexts (Figure 1). Their basic structure consists of a reinforced concrete foundation and rim, an internal waterproofing layer made of synthetic membranes (e.g., PEHD or PVC), and a protective fence installed around the basin to prevent accidental access by animals or people and to ensure safety. AWSs are typically located on flat, easily accessible terrain, with minimal vegetation nearby to simplify maintenance. When necessary, drainage channels are installed to prevent water accumulation around the basin. This type of structure is robust, cost-effective to build and maintain, and adaptable to various climate conditions.



Figure 1. Artificial water site in Dubočke, Banjani

Given the ecological characteristics of the Banjani and Golija regions, especially its karst topography and water scarcity, integrating biodiversity objectives into rural development policies, such as the strategic placement and ecological design of AWSs, may enhance the region's role in amphibian conservation. This dual-purpose approach aligns with broader environmental and socio-economic goals, supporting both traditional livelihoods and ecosystem resilience.

This paper provides an overview of amphibian diversity in AWSs in the Banjani and Golija regions, identifies potential limitations of these habitats that may negatively affect amphibian survival and reproduction, and offers recommendations and guidelines for the future construction and management of AWSs, not only in the Banjani and Golija regions but also across the territory of Montenegro.

MATERIAL AND METHODS

Data on the diversity of amphibians in the Banjani and Golija regions were collected during field surveys conducted in April, May, June, and July 2025. The study area is shown in Figure 2. The methodology involved active searching and visual observation of frogs and newts. When necessary, hand nets were used to collect and identify individuals, tadpoles, and/or eggs. Species identification was carried out using standard herpetological literature (Speybroeck *et al.*, 2016). Taxonomy and nomenclature followed Speybroeck *et al.* (2020).

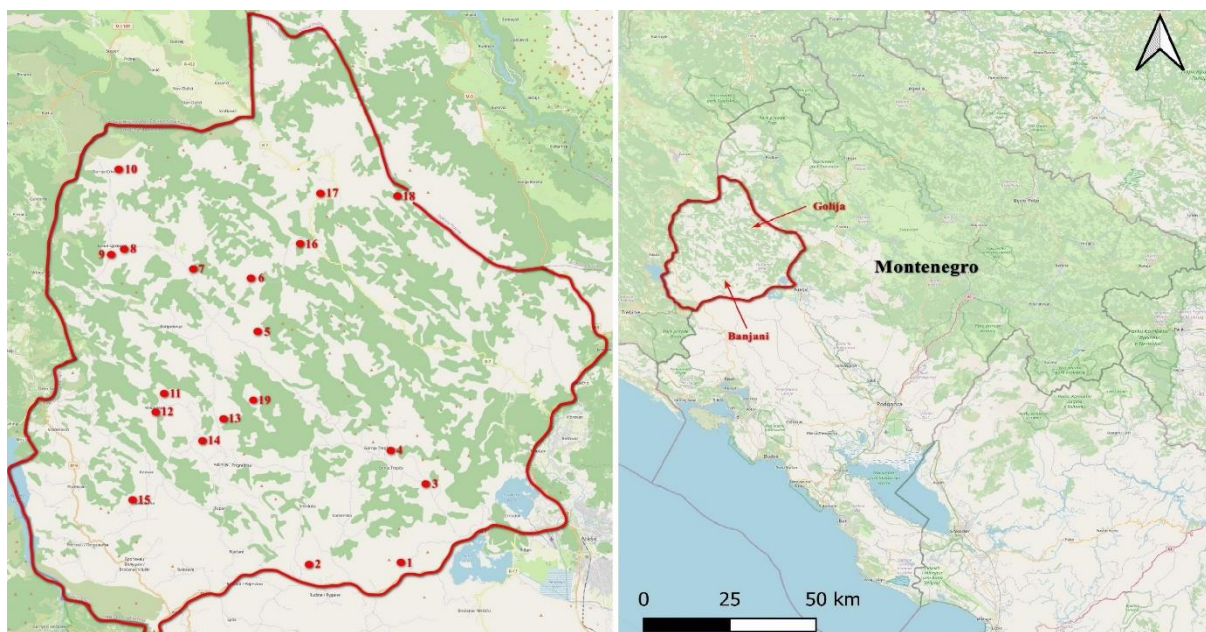


Figure 2. Study area, Banjani and Golija (Municipality of Nikšić)

RESULTS AND DISCUSSION

In total 19 AWSs were identified and visited in Banjani and Golija regions during investigated period. Most of them have been constructed by the Ministry of Agriculture, Forestry and Water Management of Montenegro since 2019, while several were built by local residents.

Each AWS was inhabited by at least one amphibian species, except for two sites in Donje Crkvice, Banjani, in which fish had been introduced; in these two sites, no amphibian species were recorded (Table 1). Dominant species was *Bufo bufo*, present in 13 out of total 19 AWSs, followed by *Pelophylax ridibundus* (present in seven AWSs), *Ichthyosaura alpestris* (present in three AWSs), *Bombina variegata* (present in two AWSs) and *Bufo viridis*, *Rana dalmatina*, *Lissotriton vulgaris* (each present only in one AWS).

Table 1. Overview of artificial water sites in Banjani and Golija regions, with details on localities, and observed amphibian species

No.	Locality	Latitude	Longitude	Observed amphibian species	Notes
1	Banjani, Trubjela	42.757954	18.789923	<i>Bufo bufo</i> , <i>Bombina variegata</i> , <i>Lissotriton graecus</i>	More than 20 dead adult individuals of <i>B. bufo</i>
2	Banjani, Rudine	42.756538	18.706763	<i>Bufo bufo</i> , <i>Bufo viridis</i> , <i>Bombina variegata</i>	One dead adult <i>B. bufo</i> ; Alive adult of <i>B. bufo</i> and two alive adults of <i>B. viridis</i> tried to went out unsuccessfully
3	Banjani, Trepča	42.810325	18.807311	<i>Bufo bufo</i>	Several dead adults of <i>B. bufo</i>
4	Banjani, Trepča	42.827729	18.773719	<i>Bufo bufo</i>	
5	Banjani, Dubočke	42.897731	18.665093	<i>Ichthyosaura alpestris</i>	
6	Banjani, Dubočke	42.933943	18.657660	<i>Bufo bufo</i>	
7	Banjani, Somina	42.942409	18.610862	<i>Bufo bufo</i> , <i>Ichthyosaura alpestris</i> , <i>Rana dalmatina</i>	Several dead <i>R. dalmatina</i> juveniles on the foil
8	Banjani, Donje Crkvice	42.954997	18.546146	<i>Bufo bufo</i>	
9	Banjani, Donje Crkvice	42.955162	18.538983	/	Introduced fish
10	Banjani, Gornje Crkvice	43.003558	18.540622	/	Introduced fish
11	Banjani, Macavare	42.864421	18.580525	<i>Bufo bufo</i> , <i>Pelophylax ridibundus</i>	One dead adult of <i>B. bufo</i>

12	Banjani, Macavare	42.856160	18.576141	<i>Pelophylax ridibundus</i>	
13	Banjani, Miljanići	42.853063	18.634703	<i>Pelophylax ridibundus</i>	
14	Banjani, Velimlje	42.833786	18.619811	<i>Pelophylax ridibundus</i>	
15	Banjani, Klenak	42.795621	18.556369	<i>Bufo bufo</i> , <i>Pelophylax ridibundus</i>	
16	Golija, Goslić	42.958233	18.696335	<i>Bufo bufo</i>	
17	Golija, Goslić	42.988501	18.720001	<i>Bufo bufo</i> , <i>Pelophylax ridibundus</i>	
18	Golija, Petrova dola	42.992342	18.782029	<i>Bufo bufo</i> , <i>Ichthyosaura alpestris</i>	
19	Banjani, Jelovica	42.866119	18.655122	<i>Bufo bufo</i> , <i>Pelophylax ridibundus</i>	

Although field surveys indicate that AWSs provide important habitat for amphibians, mortality of adult individuals was recorded at several sites. More than 20 dead adult individual of *B. bufo* were observed in settlement Trubjela (Table 1), followed by several dead adults of the same species in the settlement Trepča (Table 1). In addition, one live adult of *B. bufo* and two live adults of *B. viridis* were observed in Rudine settlement (Table 1), attempting unsuccessfully to exit the AWS. Individuals were observed slipping on the liner surface while trying to leave the AWSs.

These observations indicate that although AWSs provide important breeding and refuge habitats for amphibians in an otherwise water-limited karst environment, their current design may simultaneously function as ecological traps. Amphibians are attracted to these permanent water bodies for reproduction, but once inside they often encounter difficulties leaving the reservoirs due to the steep vertical walls and smooth waterproof plastic lining. Most amphibian species lack specialized adaptations for climbing smooth and steep surfaces, and their locomotor performance largely depends on substrate roughness and inclination (Wells, 2007; Hou *et al.*, 2008, 2010). Consequently, the smooth PVC membranes used for AWSs may represent a serious obstacle to animals attempting to escape, thereby increasing the risk of mortality. The lack of gradual slopes, escape ramps, or natural shoreline structures can result in exhaustion, injury, or drowning of both adult individuals and metamorphosing juveniles. Similar negative effects of AWSs on amphibians and other vertebrates have been documented elsewhere, where reservoirs designed exclusively for agricultural purposes unintentionally increased mortality rates of wildlife (Romano, 2025).

The repeated occurrence of dead and trapped individuals of *B. bufo* in several localities suggests that this is not an isolated incident but rather a widespread problem associated with the construction design of the investigated AWSs. Consequently, while these reservoirs undoubtedly increase the availability of aquatic habitats in the region, their conservation value

may be significantly reduced unless appropriate wildlife-friendly modifications are implemented.

Additionally, the grass snake (*Natrix natrix*) was also identified in several AWSs, with the inability to go out from them, the individuals were literally sliding on the foil. Besides them, there were also other animals as well. Two specimens of the northern white-breasted hedgehog (*Erinaceus roumanicus*) were found, one drowned and one was alive swimming in the water. Alive individual was removed from the water within the assistance of local residents. Informal conversations with local residents indicated that domestic cats have also been reported to fall into AWSs and drown.

Given the ecological importance of amphibians and the increasing fragmentation of their habitats due to rural depopulation, land-use change, and climate variability, it is recommended that future research in the Banjani and Golija regions focuses on:

Mapping and monitoring of amphibian populations – Establishing baseline data on the distribution, abundance, and breeding success of amphibian species. Particular attention should be paid to species of conservation concern or those sensitive to habitat alterations.

Ecological assessment of artificial water bodies – Evaluating the suitability of existing AWSs for amphibian reproduction and survival would provide insights into their actual conservation value. Parameters such as hydroperiod, water quality, vegetation structure, and predation risk should be assessed.

Guidelines for biodiversity-friendly infrastructure – Developing best-practice guidelines for the construction of AWSs that consider amphibian life cycles and habitat needs could significantly improve their function as conservation tools.

Integration of local knowledge, stakeholder engagement, and policy alignment – Involving local livestock farmers and communities in the planning, maintenance, and monitoring of these water bodies, while fostering coordination between conservation efforts and rural development policies, can enhance both ecological and socio-economic outcomes. Traditional ecological knowledge can provide valuable insights into historical amphibian sites and seasonal water dynamics, while stronger cross-sector cooperation within agro-environmental schemes and water management strategies is essential to ensure long-term success and funding continuity.

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ВЈЕШТАЧКА ВОДЕНА СТАНИШТА – ДОБРА ПРАКСА ИЛИ ЗАМКА ЗА ВОДОЗЕМЦЕ: СТУДИЈА СЛУЧАЈА БАЊАНА И ГОЛИЈЕ (НИКШИЋ, ЦРНА ГОРА)

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Сажетак

Вјештачка водена станишта све се чешће изграђују у крашким подручјима Бањана и Голије (Црна Гора) ради подршке сточарству и ублажавања недостатка воде. Циљ овог истраживања био је да се процијени њихов значај за водоземце и утврде потенцијални негативни утицаји на дивље животиње. Теренска истраживања спроведена су у периоду од априла до јула 2025. године и обухватила су 19 вјештачких водених станишта, у којима је забиљежено седам врста водоземаца. Најраспрострањенија врста била је обична крастача (*Bufo bufo*), присутна у 13 резервоара. Водоземци нису забиљежени у два истраживана водена тијела у која су биле унесене рибе. Иако представљају значајна станишта за размножавање, у више водених станишта пронађене су угинуле или заробљене јединке, нарочито врсте *Bufo bufo*, због стрмих зидова и глатке водонепропусне фолије која им онемогућава излазак. Слични проблеми забиљежени су и код других кичмењака, укључујући бјелоушку (*Natrix natrix*) и јежа (*Erinaceus roumanicus*). Резултати указују да вјештачка водена станишта могу имати двоструку улогу – као значајна замјенска станишта, али и као еколошке замке. Увођење елемената прилагођених дивљим животињама, као што су излазне рампе и храпаве површине, значајно би повећало њихову конзервациону вриједност. Истраживање наглашава потребу укључивања циљева очувања биодиверзитета у планирање и управљање руралном водном инфраструктуром у Црној Гори.

Кључне ријечи: водоземци, вјештачка водена станишта, еколошка клопка, крашки пејзаж, заштита природе, Црна Гора

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