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# Water Resources in Drini i Bardhë River Basin, Kosova

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## Abstract

In the present day world, the problems of too much, too little or too polluted water are increasing at a rapid rate. These problems have become particularly severe for the developing countries, adversely affecting their agriculture, drinking water supply and sanitation. Water recourse management is no more just a challenger it is a declared crises [1]. Water resources in Kosova are relatively small, total amount of water in our country is small around 1600 $m^3$/inhabitant /year [2]. Territory of Kosova is separated in four river basins: Drini i Bardhë, Ibri, Morava e Binqës and Lepenci.

Drini i Bardhë river basin is in the western part of Kosova, it is the biggest river basin with surface of 4.289 $km^2$. Drini i Bardhë discharges its water to Albania and finally to the Adriatic Sea [3]. The area consist of several small stream from the mountains, water flows into tributaries and Drini i Bardhë River. The mean run-off in the area is 141 l/s/$km^2$, but it varies considerably (5 to 50 l/s/$km^2$), precipitation varies from 600 to 1400 mm/a.

Protecting from pollution is a very important issue having in consideration that this river discharges its water and outside the territory. Hydrometeorology Institute of Kosova is in charge for monitoring of water quality.

**Key words:** rainfall, flow, evaporation, river, evaporation coefficient (Ke) and feeding coefficient from underground waters (Ku).

## INTRODUCTION

Kosova lines on the highlands (500-600m above sea level) and it is surrounded by the mountains reaching the altitude of more than 2000m. Kosova has varied geology that ranges in age from the Neo-Proterozoic to the Holocene.

Triassic formations have a considerable extension in the north and northwest part of Dukagjini lowland. The Triassic in these areas is represented by sands, clays, quartz conglomerates, limestone enriched with fauna, sandy clays and schist limestone metamorphosed with black color.

Neogene products are deposited in the laky basin of Dukagjin, which with little interruptions existed during the Miocene and Pliocene [4]. Miocene is represented by thick granule conglomerates, sands with gravels lentils, marl and limestone, while the Pliocene sediments are represented by conglomerate, sands and clays with coal interpolations. Thickness of neogene products is about 1400m.

Quaternary depositions in the Dukagjini lowland have a greater extension and are characterized with different genetic and lithologic contents. These depositions are formed during the Pleistocene and Holocene. Pleistocene depositions are represented by schist pieces, limestone, granite, dibasic, quartz and quartz conglomerate [5].

Proluvium are sediments of river flows of flood character. These products are consisted of not well circled pieces of limestone with diameter of 20-50 cm. This process continues in present days as well. Diluvium's are as a result of mechanical destruction of rocks and their content depends of geological construction of the site.

## MATERIAL and METHODS

Case study is Drini i Bardhë river basin with a surface of 4.289 $km^2$. In this river basin are based 12 hydrometric stations, 27 manual and 5 automatic rainfall measurements [6] (figura 1.).

The western part of Kosova belongs to the Drini i Bardhë river basin. Drini i Bardhë discharges its water to Albania and finally to the Adriatic Sea. The area consist of several small stream from the mountains, water flows into tributaries and Drini i Bardhë river [7]. The water balance of an area, whether it is a continent, watershed or agricultural field, can be determined by calculating the input, output, and storage changes of water. The major input of water is from precipitation and output is evapotranspiration [8]. The most basic equation for water budges is based on the hydrologic cycle, where water moves between the atmosphere and the Earth's surface [9]. The water balance for a river basin or part of it includes and outflows and servers for the computation of the regime of a catchments area. Precipitation is the sole input to the water budget under natural conditions. For water balance, as well for other purposes, precipitation measurement should be corrected for systematic measurement errors [10]. Evapotranspiration is the combination of two separate processes whereby is lost from the soil and crop surface by evaporation and from the crop by transpiration. Water evaporates from different surface, such as lakes, rivers, pavements, soil and wet vegetation. Transpiration consists of the vaporization of liquid water contained in plant tissues and the vapor removal to the atmosphere through stomata [11]. Runoff occurs when precipitation falls onto the land surface and moves toward surface waters. In a profile that meets a required characteristic of appropriate gauging station, theoretically whole runoff of its watershed is measurement [12].

Drini i Bardhe River main basin contain a big number of basins from which the most important are: Lumëbardhi i Pejës (503.5km$^2$), Lumëbardhi i Deçanit (278.3km$^2$), Erenikut (515.5km$^2$), Burimi (446.7km$^2$), Klinës (439.0km$^2$), Mirushes (334.5km$^2$), Toplluges (498.2km$^2$), Bistrica e Prizrenit (266.0 km$^2$) and Plava (309 km$^2$) fig 2.

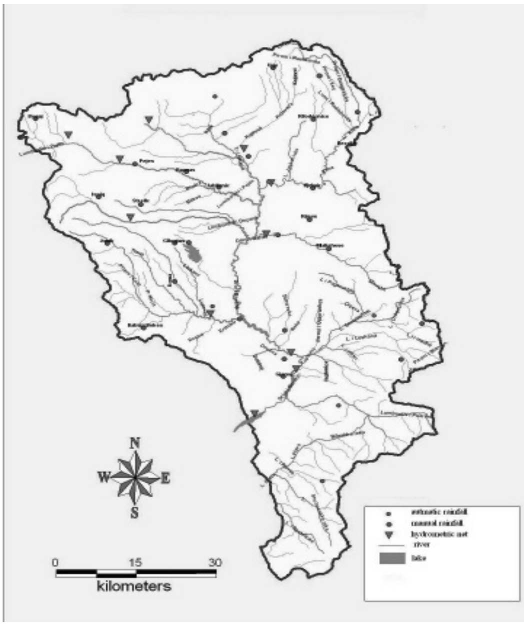


**Figure 1.** Map of Drini i Bardhe river basin with hydrometric net, automatic and manual rainfall measurement

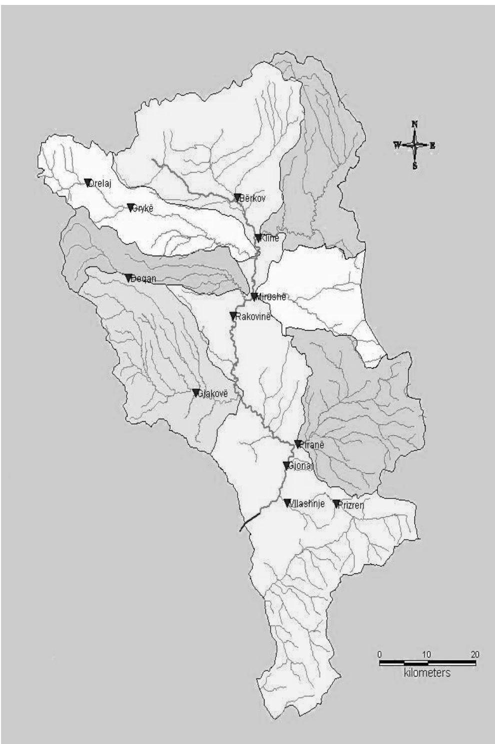


**Figure 2**. Map of Drini i Bardhë river basin and main rivers in this basin.

**Burimi river basin** – the total surface of this basin is 446.7 km$^2$ and during the year the average of rainfalls is around 335.2 m$^3$ 10$^6$. The quantities of rainfalls are changeable depending from the seasons of the year. The highest quantities of rainfalls are in November 95.0 m$^3$ 10$^6$.

In river basin average during the year flow around 139.5 m$^3$10$^6$ of water; the highest quantity is during spring while during August lowest quantity. From the total quantity of rainfalls 195.7 m$^3$10$^6$ or 58.4% isn't included in flow. The highest coefficient of evaporation is in the month of June 68.3% up to March 74%, while the evaporation is smallest from April 18.6% up to July 32.5% (tab 1).

In the Burimi river basin the average of rainfalls is around 855 mm per year, from which 317 mm flows, while 538 mm evaporates.

**Klina river basin** - total surface of this river basin is 439.0 km$^2$ and during the year the average of rainfalls is around 292.5 m$^3$ 10$^6$. The highest quantity of rainfalls is during the month of November 31.9 m$^3$10$^6$ while March is the lowest quantities of rains 17.8 m$^3$10$^6$.

From total quantity of rainfalls during the year, from the river are released around 59.3 m$^3$10$^6$ or 20.3%. This small quantity is determined from of physic-geographic changes, from which the most important are: reliefs, geological contain vegetation etc. The feeding coefficient from underground waters is 13.9% while the coefficient of evaporation is much higher 79.7% (tab 2).

In the Klina river basin the average of rainfalls is round 666.5 mm per year, from which 135.1 mm flows, while 531.4 mm evaporates

**Mirusha river basin** – total surface of this river basin is 334.5 km$^2$ with yearly average of rainfalls of 710 mm. The biggest rainfalls are during the autumn 28.7% while smallest rainfalls are during the summer 22.5% from total yearly rainfalls.

**Table 1.** Water balance of Burimi River basin

| | Rainfall (P) | Flow (O) | Evaporation (E) | Earth humidity (W) | Ku (%) | Ke (%) |
|---|---|---|---|---|---|---|
| Mm | 855 | 317 | 538 | 760 | 29 | 71 |
| M$^3$10$^6$ | 335.2 | 139.5 | 195.7 | 295.2 | 34 | 66 |
| 1/s/km$^2$ | 27.1 | 10.1 | 17 | 24.2 | 30 | 70 |
| M$^3$/s | 12.1 | 4.49 | 7.61 | 10.81 | 30 | 70 |

**Table 2.** Water balance of Klina River basin

| | Rainfall (P) | Flow (O) | Evaporation (E) | Earth humidity (W) | Ku (%) | Ke (%) |
|---|---|---|---|---|---|---|
| mm | 666.5 | 135.1 | 531.4 | 617.6 | 13.9 | 86 |
| M$^3$10$^6$ | 292.5 | 59.3 | 233.2 | 271 | 13.9 | 86 |
| 1/s/km$^2$ | 21.0 | 4.37 | 16.63 | 19.42 | 14.3 | 85.7 |
| M$^3$/s | 9.3 | 1.92 | 7.38 | 8.58 | 14.0 | 86 |

**Table 3.** Water balance of Mirusha River basin

| | Rainfall (P) | Flow (O) | Evaporation (E) | Earth humidity (W) | Ku (%) | Ke (%) |
|---|---|---|---|---|---|---|
| mm | 710 | 182 | 572.1 | 657 | 20 | 80 |
| $M^3 10^6$ | 242.5 | 60.4 | 182.2 | 225.3 | 19 | 81 |
| $1/s/km^2$ | 22.5 | 5.8 | 16.7 | 20.8 | 20 | 80 |
| $M^3/s$ | 7.53 | 1.49 | 5.59 | 6.97 | 20 | 80 |

From the total rainfalls from the basin during the year are released around 60.4$m^3 10^6$ or 25.8%. The humidity of earth participates around 657 mm from the total quantities of rainfalls (tab 3).

The evaporation coefficient is very high 80.2% while the flow coefficient is 24.9%.

**Lumëbardhi i Pejës river basin -** total surface of this river basin is 503.5 $km^2$ and during the year the average of rainfalls is around 1011.5 mm. The biggest quantity of rainfalls is in November 64 $m^3 10^6$ while less quantities are in August 29.6 $m^3 10^6$.

From the river basin during the year around 614.4 mm respectively 60.7% is evaporated from the total quantity of rainfalls. The biggest evaporations is in august (81.4%) while smallest is in May (14.6%). Because of change of psychical geographic characteristics of the river basin, in the month of May there is a flow of 5.7 $m^3 10^6$ more than the rainfalls in that month. This change is because of snow melting from the winter (tab 4).

Feeding coefficient from underground waters is the biggest in the month of March and April (around 59.1%) while it is smallest in the month of October (5.7%), the coefficient of evaporation is the highest on October (94.3%) while it is lowest on April (49.3%).

In the Lumëbardhi i Pejës river basin the average of rainfalls is around 1011.5 mm per year, from which 397.1 mm flows, while 614.4 mm evaporates.

**Lumëbardhi i Deçanit river basin -** total surface of this river basin is 278.3 $km^2$ and during the year the average of rainfalls is around 247.2 $m^3 10^6$. The biggest quantity of rainfalls is during November 12% while smallest on August 4.6% of the total rainfalls.

From total yearly amount of underground flows and surface flows are released around 293 mm, respectively 9.5 $l/s/km^2$ that correspond with yearly quantity of 90.2 $m^3 10^6$ or 2.66 $m^3/s$.

**Table 4**. Water balance of Lumëbardhi i Pejës River basin

| | Rainfall (P) | Flow (O) | Evaporation (E) | Earth Humidity (W) | Ku (%) | Ke (%) |
|---|---|---|---|---|---|---|
| mm | 1011.5 | 397.1 | 614.4 | 810.2 | 24 | 76 |
| $M^3 10^6$ | 533.2 | 196.3 | 336.9 | 433.7 | 22 | 78 |
| $1/s/km^2$ | 32.1 | 12.6 | 19.5 | 25.7 | 24 | 76 |
| $M^3/s$ | 16.1 | 6.34 | 9.76 | 12.9 | 24 | 76 |

**Table 5.** Water balance of Lumëbardhi i Deçanit River basin.

| | Rainfall (P) | Flow (O) | Evaporation (E) | Earth Humidity (W) | Ku (%) | Ke (%) |
|---|---|---|---|---|---|---|
| mm | 889.5 | 519 | 370.5 | 663 | 44 | 60 |
| $M^3 10^6$ | 247.2 | 142.4 | 104.8 | 185 | 43 | 57 |
| $1/s/km^2$ | 28.2 | 16.5 | 11.7 | 21.2 | 45 | 55 |
| $M^3/s$ | 7.85 | 4.58 | 3.27 | 5.93 | 45 | 55 |

The highest percentage of surface and underground flows is the highest during the August 93.2% while the lowest on October 38.2%. Feeding coefficient of underground waters is 43.4% while the coefficient of evaporation is much bigger 56.6% (tab 5).

In the Lumëbardhi i river basin the average of rainfalls is around 889 mm per year, from which 519 mm flows, while 370 mm evaporates

**Ereniku river basin -** total surface of this river basin is 515.5 $km^2$ and the highest quantity of rainfalls are during the winter and autumn (12.2% of quantity of year) while lowest quantity are on August (4%). From Ereniku river basin surface the yearly average of water flow is 709.6 mm respectively 361.6 $m^3 10^6$ or 11.6 $1/s/km^2$.

Feeding coefficient from underground waters is 47.9% while the coefficient of evaporation 52.1%. These two coefficients are in opposite report, as one grows the other one falls (tab 6).

In the Ereniku river basin the average of rainfalls is around 1039 mm per year, from which 709.6 mm flows, while 329 mm evaporates.

**Toplluha river basin -** total surface of this river basin is 498.2 $km^2$ and during the year the average of rainfalls is around 781.1 mm. The highest quantity of rainfalls is of November (40.8 $m^3 10^6$) while at the other months the total rainfalls are around 7.6 – 9.6% (tab 7).

The feeding coefficient from underground waters is smaller (21.5%) while the coefficient evaporation is much higher (78.5%).

**Table 6.** Water balance of Ereniku River basin.

| | Rainfall (P) | Flow (O) | Evaporation (E) | Earth Humidity (W) | Ku (%) | Ke (%) |
|---|---|---|---|---|---|---|
| mm | 1039 | 709.6 | 329 | 646 | 49 | 51 |
| $M^3 10^6$ | 538.7 | 362.1 | 176.6 | 338.8 | 48 | 52 |
| $1/s/km^2$ | 32.9 | 22.5 | 10.4 | 20.7 | 50 | 50 |
| $M^3/s$ | 17 | 11.6 | 5.4 | 10.8 | 49 | 51 |

**Table 7.** Water balance of Toplluha River basin.

| | Rainfall (P) | Flow (O) | Evaporation (E) | Earth Humidity (W) | Ku (%) | Ke (%) |
|---|---|---|---|---|---|---|
| mm | 781.1 | 232.9 | 548.2 | 698.8 | 22 | 78 |
| $M^3 10^6$ | 388.2 | 114.5 | 273.7 | 348.7 | 22 | 79 |
| $1/s/km^2$ | 24.8 | 7.39 | 17.4 | 19.2 | 25 | 75 |
| $M^3/s$ | 12.3 | 3.68 | 8.62 | 11.02 | 22 | 78 |

In the Toplluha river basin the average of rainfalls is around 781.1 mm per year, from which 232.9 mm flows, while 548.2 mm evaporates

**Lumëbardhi i Prizrenit river basin-** total surface of this river basin is 266.0 $km^2$ and during the year the average of rainfalls is around 857.4 mm. The highest quantity of rainfalls is in the spring ($64.7 m^3 10^6$). The highest flow is during the spring 86.4% from the total of quantity of rainfalls in the spring. The lowest flow is in September 4.3% respectively 42.5% of the same month rainfalls. From the river basin during the year around 32.6% evaporate the same case as the Lumëbardhi i Pejës and Deçanit, Burimi river etc, and Lumëbardhi i Prizrenit river has deficit of evaporation during the month of May. Feeding coefficient from underground waters is 85 % while the coefficient of evaporation is 15 % (tab 8).

In the Lumbardhi i Prizrenit river basin the average of rainfalls is around 857.4 mm per year, from which 590.4 mm flows, while 267 mm evaporates.

**Pllava river basin -** total surface of this river basin is 309$km^2$ and during the year the average of rainfalls is around 858.3 mm. The highest quantity of rainfalls is in autumn and winter, while at the spring is lower and in summer is lowest.

From the Pllava river basin surface during the year around 60.9 $m^3 10^6$ evaporates. In the earth humidity of Pllava river basin during the year infiltrate 139 $m^3 10^6$ rainfalls (tab 9).

Evaporation coefficient is much higher during the September (82.2%) while highest feeding coefficient from underground waters is in April (143.2%).

In the Pllava river basin the average of rainfalls is around 858.3 mm per year, from which 631 mm flows, while 227.3 mm evaporates.

**Table 8**. Water balance of Lumëbardhi i Prizrenit River basin

| | Rainfall (P) | Flow (O) | Evaporation (E) | Earth humidity (W) | Ku (%) | Ke (%) |
|---|---|---|---|---|---|---|
| mm | 857.4 | 590.4 | 267 | 649 | 59 | 41 |
| $M^3 10^6$ | 233.1 | 157.0 | 76.1 | 176.3 | 57 | 43 |
| $1/s/km^2$ | 27.2 | 19.0 | 8.2 | 20.3 | 60 | 40 |
| $M^3/s$ | 7.2 | 5.05 | 2.15 | 5.35 | 60 | 40 |

**Table 9**. Water balance of Pllava River basin

| | Rainfall (P) | Flow (O) | Evaporation (E) | Earth humidity (W) | Ku (%) | Ke (%) |
|---|---|---|---|---|---|---|
| mm | 858.3 | 631 | 227.3 | 531.3 | 57 | 43 |
| $M^3 10^6$ | 223.2 | 162.3 | 60.9 | 139 | 56 | 44 |
| $1/s/km^2$ | 27.2 | 20.3 | 6.9 | 16.7 | 59 | 41 |
| $M^3/s$ | 7 | 5.22 | 1.78 | 4.3 | 59 | 41 |

**Aquifers pollution**

Water pollution of Drini i Bardhe River basin and protection effects on measurement points – physical and chemical as well as bacteriologic analysis were performed on these profiles. Comparisons were made from profile to profile. As the consequence of the absence of treatment of sewage waters, the quality of the rivers on soils, located on plains, is rather low [13]. This has been treated since 1980, due to the fact during this period, in many rivers were highly polluted and the quality of rivers was related to main municipalities, especially to Peja, Klina, Gjakova and Prizren, in which the quality of the water is of the 3 rd and 4 th class. The polluted rivers are in contrast with pure rivers on soils located on plains, in which problems are localized exclusively around villages.

## DISCUSSION

Table 1 shows that there is a temporary loss of rainfalls, because of the mountainous relief of this basin, there is snow accumulation as reserves that will flow during months of spring.

From results of table 2 we can say that from the total amount of rainfall on average flow 59.3 $m^3 10^6$ or 20.3% per year. This small amount is conditioned from physical and geographical factors, when the most important are: relief, geological construction, vegetation etc. Evaporation coefficient in this basin is very high at 86%, whereas from the total amount of rainfalls evaporate 79.7% and 20.3% flow.

In the Mirusha River (Table 3) 657 mm (92.5% of rainfalls) are present as Earth humidity (W) during the year. Part of this amount of Earth humidity remains in vegetation, whereas some parts of it vaporize and goes back again to atmosphere.

In the Lumëbardhi i Pejës River (Table 4) because of different physical and geographical characteristics during May flow around 5.7 $m^3 10^6$ of water. This high amount of water is accumulated from the snow when it melts.

In the Rivers Lumëbardhi i Deçanit, Burimi and Lumëbardhi i Pejës there is more flow than rainfalls during the spring as a result of melted snow in those basins.

Ereniku River basin has the highest amount of water. From the total amount of flows (Table 6) around 44.8% of surface and underground flows get lost because of bad riverbed.

In the Toplluha River basin the percentage of evaporation is very low, which is unreal because during the spring months there is deficit of evaporation around -17.7$m^3 10^6$ or -31.2% of rainfalls in that period.

From Lumëbardhi i Prizrenit River basin, each year evaporate around 32.6% of water, same case is with the Lumëbardhi i Deçanit and Burimi Rivers. In Lumëbardhi i Prizrenit River, there is present a deficit of evaporation during May. In this month because of melted snow, in mountains area flows are higher than rainfalls.

## CONCLUSION

Water resources in Kosova are very much limited, so wherefore it is necessary to be draw needful strategy for their use and protection in that way that unforeseen problems will not be created in the future. The mean run-off in the area is 141 l/s/km$^2$ but it varies considerably (5 to 50 l/s/km$^2$). Precipitation varies from 600 to 1400 mm/a. The dry season is in July-August and the wet season in November-December.

Based on physical and geographical features of Drini i Bardhë River Basin and many years studies we can conclude the following:

- average rainfalls in this basin are around 852mm and the total amount of water is 3033.3 m$^3$10$^6$ (27 l/s/m2 or 10.7 m$^3$/s).
- from the basin flow around 53% of water. From the total flow in the underground flow 42% of water whereas on surface 58% of water. From the total rainfalls around 22.2% flow in the underground.
- as earth humidity (W) approximately around 670.3mm of rainfalls take part during the year.
- approximately 32% of underground water is the feeding coefficient; evaporation coefficient is 69% and flow coefficient 52.7%.
- from these results we can conclude that in the basin the average of rainfalls is 852mm, from which, 412.6 mm flows whereas 439.4 mm evaporates.

In the end we can conclude that the Drini i Bardhë River Basin, is rich with water, especially in the mountainous areas. The eastern part of the basin is poorer with rainfalls and water than the western part. Most of the water can be used properly if we build small water accumulations in the mountainous areas. These water accumulations will be used for: protection from floods, lack of water in the dry critical year periods, usage of water for power generation, water supply, industry and agriculture, and water usage for sports and other activities.

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