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Relationship between forest cover, watershed services, number of wells and water consumption in Moldova

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Abstract

The forests of Moldova belong to the first functional group, meaning their general function is a protective one, encompassing water and soil protection, climate stabilization, biodiversity conservation and social and scientific safeguarding functions. Water resources are vital for people who live in this country. Frequent draughts have had severe impacts on agricultural output, making of water management a priority concern. Moreover, excessive extraction of groundwater has caused water tables to drop. Hence, water shortage, soil erosion and flood disasters in association with forest degradation are extremely problematic in Moldova and have affected its economic growth. Nowadays, the main sources of drinking water supply are Nistru and Prut rivers, 700 springs, 4,888 artesian wells, and 136,000 wells. Almost all rural people are supplied from public and individual wells. The uneven distribution of water resources causes large differences in water consumption in different villages of the Republic. For example, an inhabitant consumes 64, 180 and 460 litres of water per day in Vulcanesti district, Orhei district and Chisinau city respectively. We hypothesize that both water quality and the number of wells depend on forest percentage cover. Moldova has at present only 325,400 ha of forests covering about 9.6% of the country and 0.01% from the world's forest area (139th place). A few centuries ago, forests covered up to 30% of this territory, which corresponds to today Europe's forest percentage cover. This paper first describes the dynamic of the forest cover and the management of forest estate, secondly the evolution of wells number and water quality, and thirdly the relationship between forest cover, watershed services and number of wells. Finally, based on existing studies, our main objectives and actions are driven by the need to restore forest quality and watershed services.

Keywords: function of water, draughts, concern, rural people, environmental service

Introduction, scope and main objectives

Because of its poorest feature in Europe (UNDESA 2013; Hugosson and Larnholt 2010; IMF 2013) in conditions of limited natural resources (Gulca, Deal 2010) and its economic growth based on consumption and on remittances (IMF 2013), the Republic of Moldova is affected in many aspects by the increasing shortage of water resources (Grec *et al.* 1994). Areas such as health, culture, social protection, and environmental protection are crucial for the country's sustainable development in the context of the National Development Strategy "Moldova 2020". Because of the impact on human health and sustainable livelihood, the topic of drinking water and sanitation facilities is becoming a seriously discussed issue among international organizations as well as developing agencies in industrialized countries (Hugosson and Larnholt 2010). When managing watersheds, human health can be seen as both an objective for management and an indicator of the overall state of the ecosystem (Parkes 2008). In that context, using the Human Development Index (HDI - a summary measure of average achievement in key dimensions of human development: a long and healthy life, being knowledgeable and have a decent standard of living), we have found that the Republic of Moldova ranks 114 rank from 195 countries in 2013. In comparison, we can see in that source about HDI that the first 17 countries with very high human development indices have a large area covered by water or even they are surrounded by water, developed sanitation facilities and most of them have high forest percentage cover and mountains.

The country's leadership pays constant and increased attention with regard to the state of wells and springs and is not indifferent towards them, proposing to institutionalize concrete actions (Mihailescu 2008). As an example in 2004, a Presidential Decree was issued on the organization of the country's annual Clean Water Week, being promoted the century-old tradition of our nation which consists in preserving the sanctity of pure water and crystal water. In fact, there are more than 20 legislative and normative acts aimed at protecting aquatic resources listed in Neculiseanu *et al.* (2007), including many laws, water code, Strategy on water supply and sanitation to communities in Moldova (2007), etc. However, 73% of the rural population has no access yet to safe drinking water (UNDESA 2013). The internet lists number of causes of illness and poisoning due to the use of water from wells: over 90% of the wells are polluted in the village Ocolina (district Soroca); because water is contaminated with nitrates and bacteria, each year the number of illnesses with gastric and intestinal diseases is increasing (31); in Calarasi district (there are 4000 wells), the water in more than 90% of the wells does not meet the parameters (32); in the village Lunga from Floresti district, the locals take out lamp oil from wells instead of drinking water (33); in the Draguseni commune (district Straseni) 23 children sickened after, according to the National Center for Public Health, they drank contaminated water from wells (34); water poisoning us, 80% of the wells contain high amounts of nitrates in the country (35).

The national legislation does not enforce clear duties to the authorities to guarantee quantitative and qualitative access to water (Guceac 2010). He emphasized "*constitutionalization of the right to water, an essential prerequisite for access to water as source of life and dignity*" and took as example the Constitution of South Africa (1996) by article 27 (1.2) "Health care, food, water and social security" where is mentioned that "Everyone has the right to have access to sufficient food and water". The author mentioned that the Republic of Moldova should analyse the legislation also from other countries like Kenya and Ethiopia. Thus, there is a well-established knowledge base around the link between land use or management practices and water quality and sedimentation (Smith *et al.* 2006). In many problems of watershed evaluation both forest and non-forest lands are involved (Duerr and Vaux 1953). In that context, the aim of the study is to stress the relationship between forest cover, watershed services, number of wells and water consumption in Moldova. The study is tackling important questions about the effects of logging across entire watersheds. And the care thinking of this investigation is if we can help to improve the quality and the quantity of water in the wells and the watershed services; what are barriers to that?

1. Methodology / approach

1.1. Study area

Moldova is situated in the South-Eastern part of Europe (Fig.1). At North, East and South it is neighboring with Ukraine, at West, with Romania. The total area 3,384.6 thousand ha comprises 2,024. 2 thousand ha of lands for agricultural purpose; lands that belong to localities: 313.1 thousand ha; surplus fund: 452.4 thousand ha; lands for industry, transport, communications and other special purposes: 59.4 thousand ha; lands of the forest fund and of nature protection purposes: 450.4 and lands of the water fund: 85,1 ha (National Bureau of Statistics 2014). From North to South, it has 350 km, while from West to East, 150 km. Minimum altitude is 1 m placed on the north of the village Palanca in valley of the river Nistru. Maximum altitude is 428.2 m placed on the Balanesti hill. The climate of Moldova is temperate-continental, influenced by Atlantic air masses coming from West, Mediterranean– from South-West and Continental–from North-East. Average annual temperature is around 9.4°C-11.7 °C. Annual precipitations decrease from North-West to South-East, from 716 mm to 531 mm (National Bureau of Statistics 2014). The highest quantity of precipitations is recorded for Codru – ancient oak forest, situated mostly in the central part of the country. Moldovan rivers are a part of the Black Sea basin. The main rivers are Nistru and Prut, which have their springs in the Carpathian Mountains. Moldova has the entrance to Danube, on a small portion of land in the South of the country. The country is divided administratively in 32 counties, 1 autonomous – territorial unit, 5 municipalities, 61 cities, 41 localities in the frame of cities, 916 villages – residences, 659 localities in the frame od

communes, all together 1,682 localities. The population of the Republic of Moldova constitutes 3557.6 thousand inhabitants with an average density of 117 inhabitants per km^2, and is urban at 42,2% and rural at 57,8 % (National Bureau of Statistics 2014).

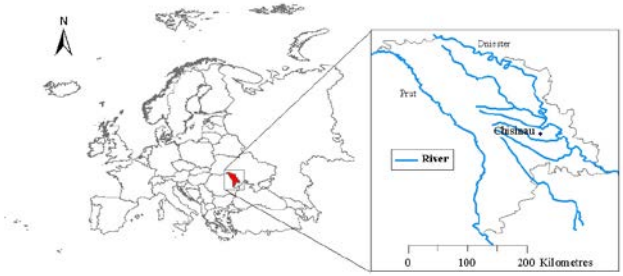

Figure 1 Location of Moldova and main rivers in the country (Hugosson and Larnholt 2010)

1.2. Methodology

In order to investigate and write this paper we completed historical analysis, reviewed documents and literature relevant to the territory now called Republic of Moldova. The study is interdisciplinary and therefore, qualitative and quantitative data were linked. Qualitative data also helped the quantitative side of the study during design by aiding with conceptual development. At present, natural resource decision-making is driven by three critical imperatives: rational scientific planning, which prioritize objective, measurable, and systematic approaches; economic feasibility and viability; and political process, which reflects power relations in decisions (McCool *et al.* 2008).

1.3. Watershed

A watershed is the area of land that feeds water into a river, through the process of precipitation draining through the landscape, into tributaries and into the main river channel. Watersheds are also called 'catchments', 'drainage basins' or 'river basins' (Smith *et al.* 2006). Watersheds are dynamic landscape constructs that are driven by what Falkenmark (2003) describes as a "hydrological imperative". The quality, quantity and timing of water draining into and flowing out of the watershed along rivers are heavily influenced by a variety of factors, including topography, geology, soil type, vegetation cover, land use, human activities *(*Smith *et al.* 2006), as well as both climate (long-term) and weather (short-term). The link between the broader hydrologic cycle, local hydrological conditions, biotic/ abiotic interactions and land uses is fundamental in predicting possible future states for a watershed setting. Global climate changes will create "hydrological imperatives" that require adaptation and management on a variety of scales. These imperatives have important links to public health, environmental justice and human security due to their influence on the wide variety of ecological goods and services provided to humans by watershed ecosystems (Parkes *et al*. 2008). The hydrographic network of the Republic of Moldova consists of four watersheds. The hydrographic network of the Republic of Moldova (Fig. 2) comprises 3,621 rivers with a total length of about 16,000 km and an average density of 0.48 km / km^2 in the north, up to 0.12 km / km^2 in the left bank of the Dniester.

1.4. Drinking water

About 70% of the population in Moldova use groundwater as a drinking water supply; however, the source only represents about 15% of all the abstracted water in Moldova. Water taken from groundwater sources (wells and springs) are of varying water quality. The remaining part of the Moldovan population is supplied by surface water but the sources are in general polluted and treatment not up to the mark. Drinking water quality suffers from presence of coliform bacteria as well as high concentrations of nitrates, sulphates, chlorine, fluorides, iron and minerals. In addition, the hardness of the water is high. A study showed that coliform bacteria were present in 16% of all sampled drinking water in rural areas, while 7% of all samples had contents of faecal coliforms (The

World Bank, 2008 quoted by Hugosson and Larnholt 2010). Nowadays, the main sources of drinking water supply in Moldova are Nistru and Prut rivers, as well as 600 springs, 6,600 artesian wells (Ropot, 1995), and about 200,000 wells. About 18% of rural inhabitants are supplied with water trough underground-centralized systems, while the other 82% from public and individual wells or a smaller part from the springs. Most of the wells tap a water table that lies between 5 and 35 m underground. Public wells (Fig. 3) are utilized by many families and are in the administration of mayoralties.

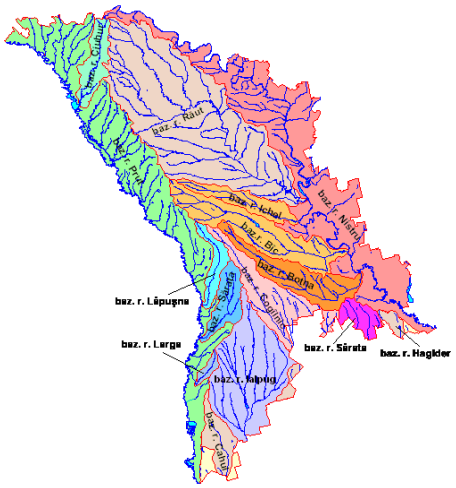

Figure 2. Hydrographic network from the Republic of Moldova (Agenția "Apele Moldovei" 2015)

Figure 3. A typical well (owner Cornea, village Butesti, district Glodeni, Republic of Moldova)

2. Results

2.1. Dynamic of the forest cover and the management of forest estate

The forests according to professor Dokuciaev cited by Przemetchii, (1923) that took in consideration the soil surface modified by forests, could cover in the past about 450,000 ha, while according to other authors forest comprised about 500 to 600,000 ha, if taking in consideration that forest covered also carbonated fallow soils, forest xerophytic chernozems, alluvions, etc. (Tudoran 2001a). Ostianu (1951) quoted by Kravciuk (1966) mentioned that if we are to add to the 500 to 600,000 ha the area of the created ravines after landslides, then the temporary forest cover in the prehistoric times might be about 1 million ha. Comparing with actual forest cover, it is evident that the use of most of the forests in Moldova has been intensive and long. First statistics about evolution of forest cover in Moldova issued

in the year 1853 indicated an area of 365,150 ha (Tudoran 2001a). The high deforestation during the19th century is evident from many statistics, while we guess that 18th century was also a black spot for forestry. We ground this opinion on historic facts about Phanariot regime (1711-1812) described in Ojog and Sarov (2001). This regime has been marked by six wars between Turkey, Austria and Russia with a duration of about 23 years on the territory of Moldova and Romania that provoked colossal destructions and stagnated the economic development. But particularly, forests in Moldova have been exploited since the beginning of the 19th century (Fig. 4).

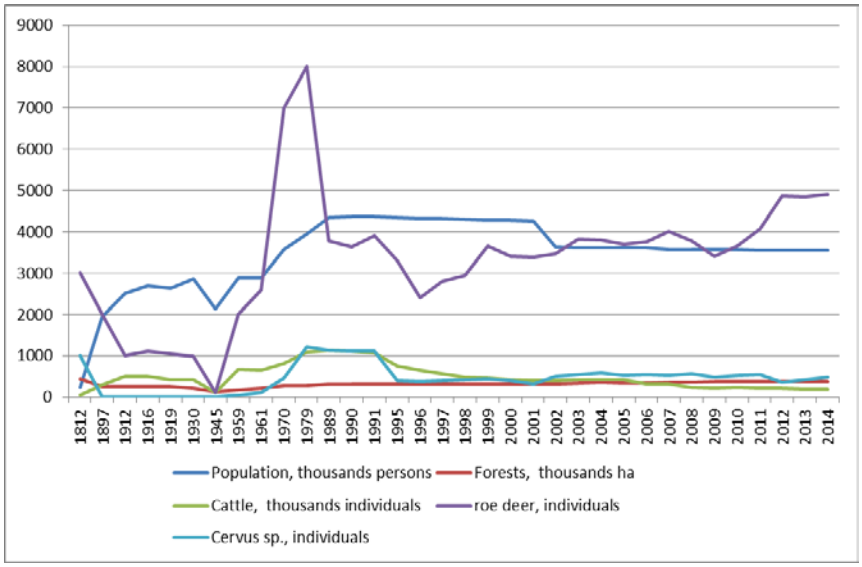

Fig. 4: Variation in human population, forest cover, livestock, roe deer (*Capreolus* sp.) and deer (*Cervus* sp.) in the Republic of Moldova during the 1812-2014 period

2.2. Relationship between forest cover, watershed services and number of wells

The relationship between forests and human water supply is often central in perceptions of water at regional, landscape and watershed scales (Malmer, 2015). The various components making up the landscape within a watershed form several groups of ecosystems. They include, for example, forests, grasslands, cultivated areas, riparian areas and wetlands (Smith *et al.* 2006). The relationships between water resources and global climate changes are therefore inseparable. Water managers are becoming increasingly cognizant of the challenge of managing water resources in a changing climate (Parkes 2008).

The uneven distribution of water resources caused the large differences in water consumption in different villages of the Republic. For example, in terms of daily water consumption, inhabitants consume in Vulcanesti district (4% forest) 64 litres, in Orhei district (17% forest) 180 litres, and in Chisinau (centralised supply of drinking) city 460 litres. The surface of forests per capita in Vulcanesti 0.06 ha and in Orhei 0.15 ha is another indicator of water quantity. The three distinct regions in terms of forest percentage, i.e. the Centre (13,5% cover), North (7,2% cover) and South (6,7% cover) are characterized by significant differences in water quantity and number of wells. Large depressions in groundwater levels were created around the cities of Balti, Chisinau, Comrat and Calarash, and many wells became empty (World Bank, 1995). In some villages of the South zone people bring water by cars for drinking, cooking and other necessities. Then the quality of drinking water has exceeded sanitary-chemical standards almost in all villages despite being from the South or North. Hence, the quality of wells' water depends on the pollution sources that in most of the cases are livestock farms, lack of sewerage systems, improperly managed waste, and mineral fertilizers.

As an example, Glodeni district with 9.3% forest cover from a total area of 76 400 ha, and around 0.11 ha per person, had 32 villages with 4,478 wells in 2002. Village Fundurii-Vechi (native of author) from this district has actually 300 wells which supply water for 3,519 inhabitants. Despite that, only one from all 300 wells fits sanitary-chemical standards, and people build every year about four additional wells. Contamination is exacerbated by ignorance of water quality (because it is often difficult and costly to taste nitrates, sulphates, etc.), people predisposed for illegal garbage disposal, and by complete lack of sensibility to the need for village sewerage. A correlation between data of population, surface, forest percentage and number of wells by counties is presented in Fig.5.

Discussion

For certain land use and land cover types the relationships with downstream water flow regimes are well established. For example, soil loss and river sedimentation is reduced in cultivated areas by farming systems using zero-tillage or agroforestry compared to cropping systems that leave the soil bare for parts of the year (Smith *et al.* 2006).

Most wells and springs are built near trails, houses, public roads, the entrances to towns where there are numerous sources of water pollution, and therefore their quality leaves much to be desired. Recent investigations showed that in many parts of the country, groundwater, where it feeds the wells and springs, is highly polluted with nitrogen compounds, heavy metals, minerals and has a high content of fluorine or does not comply with environmental requirements and sanitary norms.

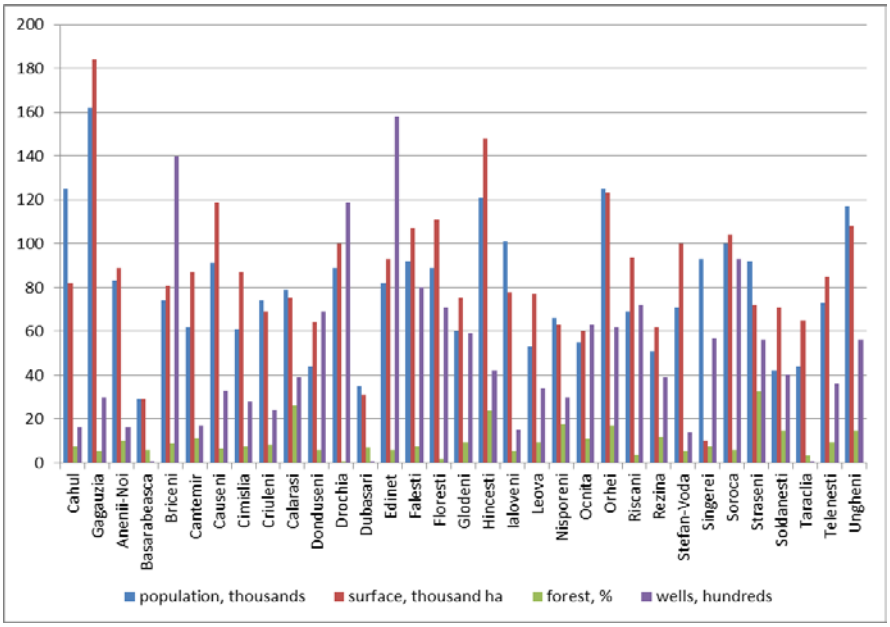

Fig. 5: Correlation between data of population, surface, forest percentage and number of wells by counties (data about population were taken from National Bureau of Statistics 2014, surface from Administrative divisions of Moldova 2015, forest percentage from Vdovii G. *et al.* 1997, and number of wells from Tapis V. 2010).

Conclusions / outlook

The largest part of human beings in Moldova is relying on groundwater resources for drinking and cooking purposes, and have presently only a few alternative options. Main sources of pollution are livestock farms, rural areas that typically do not have sewerage systems, wastes that are not placed or used properly, irrational usage of mineral fertilizers (wrong dosage and timing of application), wastewater treatment plants, industrial discharges, etc. Authorities are concentrated more on legislation an elaboration of new documents than in changing the situation, which obviously requires more finance and activity. Recommendations: preventive measures to reduce agricultural pollution (afforestation,

small-scale forestry, forest benefits, organic farming); piped supply of adequate water quality from alternative sources; connection of rural populations to sewerage and wastewater treatment plants; bio-energy.

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