Water Learning Webinar - Transcript

Dr Nowicki:

All right, so thanks, thanks everyone who has joined. We're going to make a prompt start here because we have a lot of great presentations to share with you today and we want to get through it all so I'll start off just with the agenda for the day, hopefully everybody can see this on the slides. We will have first some introductions, and then we're going to watch a presentation that's been very diligently prepared for us by PCSS Bonamoussadi, a secondary school in Douala, Cameroon, then we will have a panel of expert scientists who will present to us about groundwater and climate and I'm going to introduce those really exciting speakers a little bit later, and that'll be followed then by a bit of discussion and a Question and Answer period.

So first let me just introduce myself and my colleague Nancy Gladstone. So Nancy is the Water Programme Coordinator at the School of Geography and the Environment at the University of Oxford in the UK. I'm a researcher in the same department as Nancy. I work on water security and particularly water quality and how it impacts health. My name is Saskia Nowicki, and Nancy and I have been working together on this Water Learning Partnership for quite a few years now, so we're very excited to welcome you to this first international webinar. For those of you who don't know about the Water Learning Partnership, we have a website. This is a collaboration between researchers, teachers, teacher trainers, school administrators, and also of course students. We have developed some water learning resources and activities to understand water and how it impacts our lives in so many different ways. So we have this website waterlearningpartnership.org and there you can find the Water Module learning materials for students and also an Educator's Guide for how to use those materials with some suggestions and then on top of that you can also see activity reports and reflections from the different schools who've been part of the partnership, so if anyone's interested please do go check that website out and there's contact information there if you want to get in touch with us as well.

So, next slide, I just want to have a very warm welcome before we get to the presentations - a special shout out to the schools who have been part of the Water Learning Partnership so far - that big group photo that you can see there on the slide hopefully is Kingwede Girls Secondary School in Kenya - that's from the very first day of Water Learning Partnership activities which we did back in 2016, and then since then we've had many students from schools in Kenya, Cameroon, and most recently in Rwanda as well who have joined in the partnership activities, and many of you on the call today, so a really warm welcome to all of the students. I also wanted to welcome our teacher training partners from the pedagogic in-service training program [ISTP] in Cameroon. We would really not have been here having this webinar today if not for the excellent efforts of the ISTP team in Cameroon, so thank you to them as well and then of course a warm welcome to everybody who's joining us for the first time. We're really excited today to have registrations from 15 different countries, so it's great to see the breadth of interest across the world joining us today. Just so everyone is aware the webinar is being recorded as we want to be able to share the recording with more schools who were not able to join us live today. Some students are writing exams as we speak so we wish them good luck and we hope that they will be able to enjoy the recording of the webinar at another time! So without further delay we will get to our first presentation of the day which is from the students at PCSS Bonamoussadi. They're going to tell us about some of their water learning activities.

Environment Club at PCSS Bonamoussadi:

Greetings to you students and teachers. You are welcome to today's presentation of the webinar from here in PCSS Bonamoussadi on Lendi campus. Thanks to the knowledge obtained from the water module produced by the Oxford team in collaboration with the ISTP we have been able to acquire some knowledge from this book. We'll start by defining the water cycle the water cycle has to do with the way water circulates in the atmosphere and varies to different forms like solid as ice and snow, liquid as rainfall, and gas as by fog or clouds in the sky which appear as white or grayish water molecules in the sky which will later on fall back as rain. There are many processes that contribute in the circulation of water. We have infiltration, precipitation, evaporation, transpiration, run off and so on.

So focusing on infiltration is a process by which precipitation falls onto the land and penetrates the soil through the void spaces. This soil becomes moist because of the water, and so this water is being absorbed some of it by roots, some of it now goes down into the soil and remains as groundwater in the saturated layer.

Now we describe the infiltration experiment. The first thing we need, we need the different types of ground we are going to use. Now we use gravel, soil and sand. We need a bottle, a pair of scissors, we need thread or twine, we need a fine cloth. For our experiment, we use the containers. We use the scissors and cut from the bottom of the containers, then we drill holes through the containers and pass the thread through it so that we can suspend it on anything - we can hang it. We fill the containers with the different type of ground we are using - either one will be filled with gravel, the other will be filled with soil, and the other will be filled with sand.

We take off the lid of the container and pass a fine cloth on it. We start off the experiment. We'll try with the first one - gravel. Water is put into it and a stopwatch is started. We start timing it. We time for different time intervals - 30 seconds, one minute and so on, to see how fast the water passes through the gravel, then we try again for the soil and for the sand. We notice that at the end of this experiment, water passes faster through the gravel than through the soil and through the sand. This is because as she said the sand and the soil are more saturated than the gravel.

How is infiltration important? It's important because when water enters the ground, it helps to make the soil rich in water thereby helping the plants, especially the plants with deep roots, to grow.

How does infiltration experiment help you understand the water cycle?

This is because this experiment demonstrates the porosity of the different materials in the soil.

Two main factors which affect the infiltration of water into the earth - the permeability and porosity of the soil. Water comes from the atmosphere in the form of precipitation - rain or snow - gets onto the soil and with that the permeability of the solution which is the penetration power or capacity will enable or will measure the rate at which water can get into the soil. There's also porosity which talks of how spaced the particles of the soil are and the void space of the soil. So once the water gets into the soil, in this case now it is called groundwater and this groundwater has a certain importance, which of course the main one is being used by plants to carry out photosynthesis.

Thank you very much for your kind attention. We hope you enjoyed it!

Dr Nowicki:

All right, thank you for that brilliant presentation to the students at PCSS Bonamoussadi. I hope that everybody was able to hear that and see the presentation and if you want to make any comments or questions, you could put those in the Question and Answer box. And now it is my great pleasure to introduce you to our panel of scientists who are going to be talking to you about groundwater and climate today.

So we are going to hear first from Professor Daniel Olago. Professor Olago is the chair of the Department of Earth and Climate sciences and the Research Director of The Institute of Climate Change and Adaptation at the University of Nairobi in Kenya. Prof Olago is an extraordinary hydrogeologist. He's done a lot of research on groundwater, so he's going to tell you about that today and we hope you find his presentation inspiring.

After Professor Olago then you will hear from Professor Viviana Re who is based at Pisa University in Italy. Professor Re also works on groundwater. Her research is interdisciplinary which means that her work looks at physical aspects like understanding how rocks influence the chemistry of groundwater and she also looks at social aspects, such as trying to understand the decisions that different people make about how groundwater is used in different ways so she will be telling you a bit more about groundwater from both the physical and social perspective.

After that we're going to switch topics a bit and we're going to look at the connections between water and climate, so you will hear from two climate scientists Dr Ellen Dyer and Dr Wilfried Pokam and both of them specialize in African climate systems. Dr Dyer is one of our colleagues here at the University of Oxford in the UK and Dr Pokam is based in the Department of Physics at the University of Yaounde in Cameroon. They do research that helps us to understand the climate better and also to figure out how people can use information about the climate when making decisions about managing water or agriculture or many other things, so without further ado I want to get to the panel, but just to let everybody know that we have a Question and Answer box, so please write any questions that you have for the speakers into the Question and Answer box. You can do this while they're speaking, you don't have to wait to the end.

We really want to encourage questions that are about the topics that they're talking about - anything that you want them to clarify or maybe expand on and say more about. Please put your questions in the Q and A box and then we will come to them at the end and answer some of your questions and have a discussion. So that's all from me and I'll turn it over now to Professor Olago.

Professor Olago:

Thank you very much Saskia and a very warm good afternoon to all our students and other people who are here in this particular seminar, and I really liked the presentation by the school in Cameroon who have basically covered a large chunk of my short presentation today. Now first of all what is groundwater? Groundwater is just water in the ground, but many people have the misconception that in fact that water occurs much like surface water does, you know, in a river or in lakes. There isn't really that kind of a situation, but the water occurs in very small pores in rocks and in sediments, or in cracks within those rocks and fractures, and that is where our groundwater comes from, and why is groundwater really important to us? It is a major source of water for people who live, particularly, in arid areas, where there isn't enough surface water - no rivers, no lakes, and all the water that they can get which is fresh is really within the ground...and if you take the global situation, about 97 percent of the water that we have is not fresh water, it is sea water, and groundwater - all of the groundwater in the world - will constitute something close to about 2 to 2.5 percent, but when we look at fresh water itself, most of our fresh water is in the ice caps and in glaciers, and of that

percentage, which is roughly about 1.7 percent, we have 30 percent of it is in groundwater and the remaining about 70 percent is in the ice caps and glaciers, and just about one percent is in our rivers and lakes and in swamps and other water bearing bodies.

So you've heard about the water cycle and it is extremely important, because the source of groundwater is rainfall, and that rainfall infiltrates into the ground, gets into the - what we call - aquifers. These are water-bearing rocks and sediments - we call them aquifers - and this is where the water sits, and aquifers can be very shallow and also very deep - we have freshwater aquifers that are being exploited which are even up to 700 meters below the ground, but normally we target between - you know - five to about 100 to 300 meters in most cases around the world. So those two properties of an aquifer which is porosity - you know - that's the amount of space that is in those rocks and sediments that can hold water, and permeability: the interconnectedness of those pores which allows the water to flow, and it it is what allows us to actually be able to get this water out of the ground to the surface and to use it for drinking, or for irrigation, or for watering our livestock or for other different uses that we may have.

So, when you look at our continent of Africa for example, we have about 43 percent of the continent being a dry land area. In essence, the main source of water for people living in these areas is groundwater and two out of five Africans are living in the dry land zones, so this becomes an extremely important water resource, but our dry lands are also quite important in the sense that they support a huge variety of biodiversity - you know - wildlife for which much of the continent is well known - you know - really interesting flora and fauna across the entire continent. So, groundwater then is a resource that really needs to be protected. We need to be able to protect it from pollution, for example, or from over-abstraction.

The reason why groundwater systems are easily polluted is simply because they follow the water pathway - as the rain infiltrates into the ground the pathway that it uses is exactly the same pathway that is used by polluting substances, and we have a lot of underground structures like, you know, we can talk about pit latrines, for example, or pipelines which are for sewerage, or for oil and others, and all of these can pose a danger to contamination of our groundwater systems.

Now the groundwater systems are also very important in the sense that apart from supporting human beings, they support wildlife - they support flora and fauna. And society really needs water so it's a social ecological parameter that is extremely important linking the entire living set of organisms in one way or another, and that is why we say water is life. Without water we wouldn't have any of these living organisms surviving. Now in the context of climate change, we know that groundwater is one of those water storage systems - a groundwater aquifer is a water storage system that buffers us from the impacts of climate change because the water that is stored underground is not prone to evaporation for example, like water which you have in lakes and in rivers, and it is also because of the natural infiltration process it is also, it also tends to be fairly fresh and unpolluted, unless it is polluted intentionally by human activities, or has a natural pollution because of the type of the geology within which it occurs, but otherwise the groundwater is a real buffer against climate change because of those particular properties.

Now, one of the things that we also now know about our groundwater systems in the dry lands, because it was a big concern that how water secure can we be going forward into the future under a trend of say declining rainfall amounts and hence less water to recharge the groundwater systems? But we find that in fact, heavy rainfall events which are predicted to become more frequent and more intense in the future actually really is a powerful recharge mechanism for groundwater systems, so in that sense then going forward what we can expect is that groundwater systems are really key to helping us to buffer our water quality needs, water needs for safe water, for clean quality

water going forward into the future. So we do have also some technologies that we use to help us to have more groundwater in particular areas, and these include some age-old centuries-old technologies like sand dams and also more recently we talk about Managed Aquifer Recharge where we intentionally direct surface water into groundwater systems and store them there and then extract them for our own use later on. So that is what I really wanted to share about groundwater - short and precise - but if you have any questions I'm very happy to take them on. Thank you very much. Back to you Saskia.

Dr Nowicki:

Thank you so much Professor Olago, that was a really interesting presentation! I hope everybody enjoyed. We have a question already in the Question and Answer section which is great. We will get to that at the end of all of the presentations. If anyone else has questions for Professor Olago please don't hesitate to put those into the Question and Answer section which you can find at the bottom of your screen there should be a little chat box and it says Q and A. So now we'll go next to Professor Viviana Re, who's going to talk to us a bit more about groundwater from a different perspective.

Professor Re:

Thank you Saskia and greetings everyone. I'm sharing the screen with a couple of slides. Can you please confirm you see everything? [Yes that looks great.] Thank you so much so again, greetings everyone and thank you for joining this very interesting webinar and for sharing also the experience from this very important and interesting experience. So we learned from Professor Olago how important is groundwater for well-being and ecosystems, and also we learned that hydrogeology - so the discipline that actually targets the studied investigation of groundwater resources from the physical and also the chemical perspective - can allow us to answer many many questions, so the origin of water, which could be the pollution sources both natural pollution in terms of geogenic contaminants by the side or anthropogenic pollution. We can learn about recharge rates the - infiltration as we said before from the presentation from the students, and then from all the hydrogeological settings of a specific region we can learn where the water comes from, which could be the pathway and so the 3D dimension of groundwater which is crucial to understand and assess and also to protect the water resources. But as Saskia mentioned in my nice and kind introduction, we can also consider to add a second component because we have a very important and strong relationship with groundwater resources.

All over the world groundwater is the main source of fresh water for domestic and also agricultural consumption, so there is a strong social relation, so each of us has a strong relation with water resources and groundwater in particular. So we can also combine the study of groundwater, so the hydrogeological study of groundwater resources, with the social component, and thus to try to go a step further and look at the broader picture, so not only focusing on the well in the 3D dimension, but also to assess the connection we have with water resources, so if we study a region or aquifer or a portion of a catchment we can ask and learn, with the integration of social sciences, how much water is used for which purposes; who is managing this water resources; which take care of that; who is responsible for fetching the water; for what which use is it taken; how far people have to walk or to go for collecting water; also we can learn a lot about the cultural value of water resources. Each of us and each culture is different so we each of us have a different perception and different tradition that relates and link us to water resources. So by integrating the disciplines or integrating hydrogeology with social sciences for example Behavioural Sciences or socioeconomic assessment we can learn more and integrate this information with the information that hydrogeology gives us and to have full picture so

have put a better understanding of these resources and learn more what we can do in the long run to protect these resources.

So in addition to that with the social, the social word in socio-hydrogeology indeed includes the integration and incorporation of social sciences with hydrogeology in what we say interdisciplinary approach which means that different disciplines work together cooperate and learn from each other in this sense there is a strong integration. However, with the social, we can also go a step further and try to understand better this relationship, the personal relationship we have with water resources. So with the integration of social sciences we study that from a scientific perspective but then we can have the bottom-up approach so understand and integrate better the perception and the relation and the value that each of us has with the water resources in a specific region, because we have learned that in most cases the water that comes from the tap of our homes or our offices or our well, either a community well or a private household well, most of the cases is groundwater, so we have a very personal relationship with groundwater, so we can integrate also this knowledge and this relationship in the protection of water resources and thus "socio" in this case goes further, which means including and integrating the social community, the local community, that live in a specific setting and exploit or use the water resources in this specific area and this means that we can integrate the local indigenous knowledge into the assessment, in the hydrogeological assessment and learn from local practices, long-term strategies for management of water resources and this means that we can integrate something that is more well-structured like hydrogeology with the social settings, the local value, the local knowledge that we have in each communities, because we know that and this is the interesting part of being in a very diverse world, we have very different cultures, we have very different approach towards water resources beliefs and also perception of contamination and this means that one size fits all for the approach for the protection of water resources may not be so effective, so we need tailored solution for any specific case study, so to integrate something that as I said is a bit more static, let's say, or structured like hydrogeology with the specific component of the local, the local setting, the social and cultural setting of these any specific region.

So with this we call transdisciplinary approach, because it involves not only different disciplines but also the local communities or the people that have an interest both direct or indirect with these groundwater resources and we engage with them, we do not only inform people about the findings of our research but integrate the knowledge of all the people of a specific community into our investigation so we can go a step further in unveiling the connection that water resources are with people and particularly we know that groundwater most of the time we cannot see it because it's underground, we cannot see, but also this connection we know that they are present, we perceive them but they are invisible, so with this integrated approach we can really unveil and make more visible this connection and this would allow us to eventually find a solution for the long-term protection of water resources.

So I hope that this is a very very brief overview of the complexity probably that we need to tackle to learn more about water resources would encourage you to engage in transdisciplinarity, in going a step further in the protection of water resources and it will encourage you to include your own culture and your knowledge as a step which is fundamental for the protection not only for the local water resources but also the global resources worldwide, and of course very short overview but I'm happy to answer any question afterwards either in the chat box or later after the webinar. Thank you so much.

Dr Nowicki:

Wonderful, thank you very much, Professor Re. I hope everybody enjoyed that really interesting perspective presentation about the socio-hydro approach to groundwater, so if anybody

has questions for Professor Re about her work and what she was talking about please put those in the Q and A section. So both Professor Re and Professor Olago mentioned how groundwater is an important resource when we think about climate change and climate resilience, or resilience to climate change, so we're gonna spend some time now to hearing about climate more specifically, so I'm going to turn over to Dr Ellen Dyer and take us away...

Dr Dyer:

Good hi everyone. Yeah so we're going back to the water cycle and we're gonna fill in some more detail of what's going on above the ground. So just like rainfall can drive groundwater recharge their local surface processes like evaporation and transpiration from forests that can contribute to driving the cycle and in central Africa evaporation and transpiration from forests is really an important driver of rainfall, and so evaporation is a change of state - water goes from being a liquid to being a gas and this requires that water to be heated up. As the water vapor or gas moves up through the atmosphere it will eventually condense and can become precipitation. So the picture of the this cycle is quite static, it's very simple, but this schematic here includes something that's very important to us, and that is transportation. So now I hand it over to Wilfried to tell you a little bit more about variability and that important feature.

Dr Pokam:

Oh yes thanks, although we have this water cycle over all regions of the world, the way this water cycle happens or the quantity of each of these components varies depending on where we are in the world. For example, if you consider where you live from one day to the next, if it is a rainy season you don't have the same amount of rainfall that can be recorded, and also if for example to take the example of Cameroon, we have the southern part which receives more rain during the year compared to the northern part which is more dry. Also if we consider the location, if you are close to the equator or if you are far close to one of the poles, the quality of the precipitation is not the same. Close to the equator, you have liquid water as precipitation, but close to the pole you have ice in the form of snow, so the the type of precipitation is not the same across the world, so there is a strong diversity in terms of each of the component of the water cycle depending on where you live. Next slide.

And in the case of Cameroon specifically, if we want to look closely what makes rainfall variability one important aspect is the topography. In Cameroon, we have the Mount Cameroon which is located along the coastal region, and because of this location and moist air coming from the Atlantic Ocean, in Cameroon we have a village called Debundscha which is one of the more rainiest location in the world, and this is a combination between this moist air coming from the Atlantic Ocean and the location of this village between the coast and Mount Cameroon. Next slide. So another important feature which strongly impacts the amount of rainfall we can have in Cameroon is the dry air coming from the Sahara, the dry area across the northern part of the African continent, so you have this dry air coming and when this air covers many parts of the country we have less rainfall, while when this air is not coming a lot into the continent we have rainfall. Another climate feature which strongly impacts the water cycle precipitation over Cameroon is some winds that blow from east to west across the country at around four kilometres above the ground, so for the students to clearly understand the direction of those winds, you can suppose that they blow from the city of Bertoua to Douala, so this winds when they are very strong, there is less rainfall over the country and when they are weak there's a lot of rainfall. The rainfall amount is higher during the rainy season mainly from September to November. Next slide.

Another important climate feature which also impacts the quantity of rainfall is the moist air coming from the Indian Ocean. It's true that because of the topography across the East African continent, the contribution of this moist is much more efficient in the East part of the Southern African

region but it also contributes to rainfall variability over the continent and also we all know that in Cameroon, in the southern part of Cameroon, and in many parts of the Central Africa region we have the Deep Congo Forest, which surely contributes to evaporation of water and brings a lot of humidity in the atmosphere which contributes rainfall over the region. Next slide.

Dr Dyer:

So Wilfried talked about all the different features that might influence rainfall by changing moisture transport in Cameroon, but these local atmospheric conditions can also be influenced by the climate in other parts of the world which is called a teleconnection, and one important example that might be familiar to you is the El Nino Southern Oscillation. So sometimes you'll hear we're in an El Nino year or a La Nina year for example, and this is due to changes in the ocean temperature in the Pacific Ocean and what this does is change the strength of the winds in that ocean and also how much moisture is available in different parts of the ocean, and even though this is a feature in the Pacific this can influence the climate all over the world, so changes in the winds and ocean temperatures there can also influence changes in temperature and winds in other regions, and it can influence the amount of moisture that is moving around different parts of the world and therefore this can influence the water cycle. So this - the El Nino Southern Oscillation - is called an oscillation because it kind of swings back and forth between an El Nino State and a La Nina state, and the plot that we've got up here is what the world kind of looks like when it's in an El Nino state, so things sort of vary back and forth between these two kind of extreme states in the Pacific and it has a really big influence on local climate all over the world.

And the question is why does variability like this occur and why is the climate so variable? And the reason for this is that the Earth is a big rotating sphere and the sun heats up different parts of the earth more during certain times of the day and the year, and there are continents that are barriers for ocean water, and also for winds, which is basically a fluid moving around in the atmosphere, and also there's moisture in the air along with other gases that influence the temperature of the air and how it moves around in the atmosphere, and so what we have here is a video from the Galileo satellite which looked back at Earth and actually you've got the African continent up in the right corner, and you can see how the clouds, because it picks up the the vapor in the atmosphere, are swirling around and interacting with the land mass as well.

Yeah, then the question is you know we know we kind of understand some of the features that are influencing climate, how features are around the world are influencing each other, but how might these change in the future because of climate change and what is the mechanism for this? So greenhouse gases are gases in the atmosphere that absorb radiation like radiation from the Sun and these can make the atmosphere warmer, and a warmer atmosphere can mean a warmer surface. A warmer atmosphere also has the ability to hold more water, because as we said at the beginning condensation and evaporation is related to temperature, so the questions to think about with this is - if the surface is warmer, but the atmosphere is wetter what does this mean for climate variability? and also will the effects of this be the same everywhere? Over to Wilfried

Dr Pokam:

Yes, so to understand how all these change will happen in the future, one of the key tools that I use is the climate model, so in common models there's a representation of all mechanism and interaction you can have in the atmosphere, so it helps to better understand the functioning of the climate and how it will vary across the time, so all the processes that have been explained for the water cycle, all these processes are represented in these models, so all the equation linking all the variables will explain the water cycle. All those are represented in this in these models, and a cloud model is

simply - it's a software on which you have all these mechanisms which are represented, so on that way it's possible to simulate how the climate is functioning, and predict how it will change in the future.

So you are all well aware about the global warming, and as Ellen said, with the increase of temperature, the water which is kept by the atmosphere is also high and the last information we have from the science, we can it bring a lot of confidence on the the trends in terms of increase of temperature we have across the surface and one of the main consequences is the intensification of the of the water cycle, so the last information we have from the science is that with the global warming the water cycle will intensify, and this is supposed to become more stronger in the future.

Dr Dyer:

And models also allow us to predict the future at shorter time scales, so this is an example of a seasonal rainfall forecast for East Africa and so this shows where you would expect there to be above normal rainfall, normal rainfall, or below normal rainfall with probabilities, so the different types of climate information for models can help you make different types of decisions. So they can help us figure out how different parts of the climate are connected, and also how they might change in the future.

But finally one really important question and I have a bunch of questions here for you is how we make climate information useful and usable. A big challenge is to make information for models useful and available to people who need it. How do you get a forecast if you live in a remote area for instance? Another challenge is to make it easy to use. Can you understand the forecast map I showed earlier and how you might use it? And finally uncertainty and projections and forecasts because these are imperfect tools modeling a very chaotic and complicated system makes using climate information hard. Do users trust it and can they trust it enough to make decisions with? So a final question for everyone is what climate information is useful in your life, and how do you use it? Thanks for listening, and we look forward to your questions.

Dr Nowicki:

Wonderful. Thank you very much to Dr Dyer and Dr Pokam for that really comprehensive and interesting presentation about water and climate. We've got lots of questions in the Q and A section now, so we're going to have a bit of a discussion, so I'd like to ask all of the panel to turn your videos on and hopefully we have good enough bandwidth that we can manage to have everybody visible. So my first question which is actually it's a bit of a two-part question, and this is coming from the Baptist Comprehensive High School Soppo. They've asked a question that is connecting groundwater and climate change, so that's why I'm starting with this one. The question is: Can the volume of groundwater reduce, or will its temperature get warmer or colder because of climate change? And then the second part of that is: After using large quantities of groundwater, is it possible that it will get finished? So a two-part question here about, yeah, the amount of groundwater - whether it will reduce and how it might be impacted by climate change? I'll go first to Professor Olago and then if any of the other panellists want to follow up and give a bit more on that question. We'll do that, thanks, okay.

Professor Olago:

Thank you very much. I'll try to be very brief. Yes, the volume of groundwater can decrease because it is a finite resource, and in that context we talk about the sustainable use of groundwater, so remember that we say that groundwater gets recharged by rainfall, so if we use just the amount that recharges that groundwater system from rainfall, just that amount in the storage in groundwater, then we are going to retain the capacity of our groundwater system to provide us with water. So yes, it can reduce and when that happens we refer to it as over-abstraction of the groundwater system.

The second is about temperature. Groundwater which is near the surface is of course affected by temperature increases or decreases but we have groundwater which is much deeper, anything from say about 20 to 30 metres and below that is kind of isolated from the temperature effects at the surface of the Earth, so those particular deeper groundwater systems tend to retain a very stable but lower temperature than we would have on the surface of the Earth, thank you.

Dr Nowicki:

Thanks Professor Olago, do any of the others want to add to that? A very comprehensive answer so maybe we can we can stick with that and we have lots of other questions so the next question I'd like to ask is a bit of a combination. So we have a question from BCHS Nkwen and PSS Bafut so two different schools both asking about the water cycle - so the water cycle and how rainfall varies in different places. So the question is: Climate change is manifesting itself in terms of increasing rainfalls, but why is the situation in the deserts not getting better?

And then from the other school it was: Water is neither created nor destroyed in the water cycle, so why does water shortage occur in the environment? So I'll put this question to our climate scientists, whichever one of you wants to jump in. You go first, Wilfred.

Dr Pokam:

Yes about the increase of water because of climate change and the drought area we still have - is that the consequence of climate change is not only the increase of extreme rainfall, another consequence is also the increase of dry conditions in some areas, so there is a strong diversity in terms of impact across the world, so depending on the region you can have a strong increase in rainfall, or you can have a strong decrease in rainfall, so because of climate change there are some regions which are supposed to be more drier than it was now.

Dr Dyer:

And then on the other part of the question we highlighted transportation at the beginning of our slides, and that's a really important point to answer that. So yes water is not created and destroyed at least in this scenario, but it can be moved around, so you can have a lot of evaporation happening over a lake or a forest and it will be moved because of winds to somewhere else so you won't get the benefit of having rainfall from that evaporation, so understanding of circulation features like Wilfried was highlighting it's really important to understand where water will end up as rainfall.

Dr Nowicki:

Great, thank you both. So the next question will be for Professor Re this is a really big question. So the question is: how does human activity impact the water cycle? And I was hoping maybe you could give us also a bit of an example from some of your research - you mentioned local knowledge about groundwater use and how you integrate that with some of your other work, so perhaps an example and yeah, an answer to that big question.

Professor Re:

Yeah it's like a big question, but I think we have two or three hours no to discuss this probably no? Very briefly I think that we have to remember that water is essential for our lives, so basically every activity that we have somehow influences water, so Professor Olago mentioned about the exploitation, of the use of water resources, and this reduces the the quantity of water resources, then we have the other activities - the contamination, the pollution - that can affect the quality of water resources, so we may have different aspects, so we have agriculture that influences a lot the the quality in terms of increasing pesticides or nutrients such as nitrates, and then we have all the new, let's say,

contaminants which are called contaminants of emerging concern - so we have pesticides which are probably not so new but then we have all the antibiotics, pharmaceuticals, and so on and so forth - even microplastics. So we have to remember that each activity we do somehow impacts the quality and the quantity of water resources so knowing the activities and the uses of water can also help us to protect the water resources, and we have to remember that, for example, even the clothes that we wear are made of water because water is used for growing the cotton for example, and then it's used for the industrial process and the transport process may also involve water, so again talking about something invisible, we have water everywhere, you know, the food that we eat, the clothes we wear, the tools we use, so that's why I think it's very important to be more aware of the connection that we have with the water resources, and also learning what can create harm, either in terms of overexploitation or contamination, so well, there should be many many examples but probably I think each country may have different specific issues, but all I think can be solved if we all engage for the protection of water resources, thank you.

Dr Nowicki:

Thanks, a great answer to a difficult question. Actually they are all very good challenging questions, so thanks to the students for challenging our panel today, so we have another question here. Actually there's quite a few questions in the chat about the purity of water, and this one was directed to Professor Olago. The question is: What are the processes involved in purifying groundwater to make it fresh? So perhaps if you could say a bit about that. Some others were also interested in desalination of seawater and options as alternatives.

Professor Olago:

Okay yes, thank you now I think it's important for us to know that the kind of systems that we have put in place to purify our water really mimics the natural environment. So we have for example when we are purifying water that is abstracted from a lake and it goes into a water treatment plant, we actually filter, pass that water through filters, and those filters include sand and gravel, and so think of it that when it rains and this water is seeping through the soils and the sands and the gravels, and into the aquifer system that filtration process is removing pollutants like you know, chemicals, it's removing harmful bacteria like E. coli and other, so just that natural filtering process allows that water to be clean and safe to use once it enters into the groundwater system, and again, if you think about desalination, the process is similar. Ever since the oceans formed, we have a natural desalination process taking place. Ocean water gets heated and what gets up into the atmosphere and is transported as moisture and precipitates on the continents is just the molecule water H2O, leaving behind sodium, calcium, sulfates, chlorides and all those other elements in the sea water. That is a natural desalination process but desalination in and of itself in technological terms is a very expensive exercise, because once you have produced your your water, you need then to remineralize it. While this happens naturally in the natural world, remineralization will require us to add these elements - important elements like sodium and others - into the water system so that we can get them macro and micro-nutrients that we need from water. So basically that is it, so desalination is just an expensive process, but it can be applied at different scales, even locally you can do it - you can have desalination plants using you know solar powered panels, and you can get here two or three litres of water quite easily, but you have to remineralize it.

Dr Nowicki:

Thank you Professor Olago, an excellent answer to another challenging question. We have about four minutes left until we reach the hour. If you are able to stay a bit longer - to the panellists - there are quite a lot of really great questions there that you might be able to type some responses to, so perhaps have a look through. Ellen, there's a question about climate information I can see you're

already starting to answer so that's great, but just before we wrap up, I also I wanted to ask Professor Olago and Dr Pokam, since you are based in Kenya and in Cameroon, if you have advice for some of the students if they're interested in this topic about water, groundwater, climate, what would you recommend to them in terms of what to focus on in their studies, or what they can do to kind of develop their knowledge in this area, so maybe go to you first, Dr Pokam, if you have any advice for the students who are interested in this topic in Cameroon.

Dr Pokam:

Yes, what I can say is that I think for what we have or what they are studying now in the curricula, they have some lessons which focus on some of the aspects of the water cycle, so my suggestion will be to try themselves, they have access to many content online, so I will suggest them to go further on what they receive at school and try the way to understand some of the process or some of the items they have learned during the courses then try to go deeper in, because the water cycle is very large, it's very difficult to really have, I don't know, one document that can really explain it all, but the the direction really is to take what they have they received at school as the entry point and try to go further in. That will be my suggestion.

Dr Nowicki:

That's great, thank you. I really agree. I think it's amazing once you start looking at water and realize how it's connected to so many things, it becomes a huge huge subject very quickly, so I think that's great advice to really focus and try and follow up on the areas that are most interesting. Professor Olago, do you have any other advice that you'd like to give to the students?

Professor Olago:

Yes, just to add that it's really highly interdisciplinary, multidisciplinary, this issue of water, and we can see that from the range of the short talks we have had today, we can see just you know how many different, you know, disciplines and subject areas that it encompasses. So yes, it would be good if, depending on which particular aspect that you want to concentrate on in water, you know, you need to have at least a little bit of mathematics, some chemistry, physics - you need to understand how water relates with the biological systems, and a host of other things, you know, atmospheric sciences and oceanography, and all of that so it's quite highly interdisciplinary, and there are many institutions that offer these programs at the Bachelor's degree level, so you are free to take your pick on which particular course you'd want to take. Thank you.

Dr Nowicki:

Great, thank you, Professor Olago. So we are at the hour now and I can see some answers being typed into the Question and Answer, so if we haven't managed to get to your question yet and you can wait a minute just hang on and we will try to put some answers written into the Question and Answer section but for those who have to go, I just want to say a really big thank you to everyone for joining us today for all of your really good, challenging, relevant questions and we really hope that you've enjoyed the presentations and yeah, look forward to connecting with you more in the future so thank you very much from the Water Learning Partnership and thank you to our really excellent panel of scientists who have given us so much to think about today. Thank you very much!