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ASSESSING FOREST FUNCTIONALITY TO PROVIDE SERVICES RELATED TO WATER RESOURCE

An innovative tool for South Pacific Island countries

LESSONS LEARNT REPORT

January 2020

WWF

WWF is one of the very first independent environmental protection organizations in the world. With an active network in more than 100 countries and with the support of nearly 6 million members, WWF works to halt the degradation of the planet's natural environment and build a future where humans live in harmony with nature, conserving global biodiversity, ensuring sustainable use of renewable natural resources, and by promoting the reduction of pollution and waste. Since 1973, WWF France has been working on a daily basis to offer future generations a living planet. With its volunteers and the support of its 220,000 donors, WWF France is taking concrete action to save natural environments and their species, promote sustainable lifestyles, train decision-makers, support companies in reducing their ecological footprint, and educate young audiences. But for change to be acceptable, it can only happen through respect for everyone. That's why WWF's philosophy is based on dialogue and action.

Together possible.

Contacts

Emma Do Khac, Forest Program Coordinator of WWF France office in New-Caledonia
edokhac@wwf.nc | +687 27 50 25

Hubert Géraux, Head of WWF France office in New-Caledonia
hgeraux@wwf.nc | +687 27 50 25 / +687 83 36 70

Remi Andreoli, Director of Space Applications, Bluecham
remi.andreoli@bluecham.com | +687 28 97 95

Partner contacts

Direction of Veterinary, Food and Rural Affairs of New-Caledonia, Water Service – (+687) 25 51 38 – davar.sde@gouv.nc
Service of Environment of Wallis and Futuna – (+681) 72 05 97 - senv@mail.wf
Department of Water Resource of Vanuatu - (+678) 22423 / 33435 - esteitoka@vanuatu.gov.vu

Graphic design : **Maëlle Naut, Thomas Pesci**

PROJECT PRESENTATION

SDGs target

In 2015, the UN adopted 17 Sustainable Development Goals (SDGs), aiming to "protect the planet from degradation…so that it can support the needs of the present and future generations". Through the SDGs, the UN recognises that conservation directly supports human health and wellbeing by providing goods such as water and fibre, and global public goods such as habitats for species and mitigation of climate change. Although trade-offs can indeed arise between conservation and economic development, the Rockefeller Foundation–Lancet Commission on planetary health states unequivocally that "the environment has been the foundation of human flourishing", suggesting that if environmental degradation persists then ongoing improvements in human health are likely to be reversed.

The SDGs targets on which the project focuses are:

SDG 6 - Clear water & sanitation

6.5 By 2030, implement integrated water resource management at all levels, including through transboundary cooperation as appropriate.

SDG 11 – Sustainable cities and communities

11.A Support positive economic, social and environmental links between urban, peri-urban and rural areas by strengthening national and regional development planning

SDG 13 - Climate action

13.1 Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries.

SDG 15 - Life on land

15.4 By 2030, ensure the conservation of mountain ecosystems, including their biodiversity, in order to enhance their capacity to provide benefits that are essential for sustainable development.

Countries :

- New-Caledonia
- Vanuatu
- Wallis-and-Futuna

Data types and technologies

- Administrative data
- Geospatial data
- Satellite imagery

Project objective

This project aims to assess the functioning levels of forest ecosystems in watersheds that supply water catchments through an innovative and low-cost tool based on geospatial data. It considers ecosystem services provided by forests and calculates parameters that translate them into spatial indicators. The method is to be replicable and cheap so that a long-term monitoring can be done, and provides information that can be used by elected officials and managers to help securing water resource through green infrastructures.

EXECUTIVE SUMMARY

In early 2016, WWF launched a pilot study to assess the functioning levels of existing water collection protection zones in New Caledonia by defining a forest ecosystem function based on the loss of water-quality-related ecosystem services.

The project relied on existing data and offered a reliable methodology based on satellite imagery analysis to assess and monitor this forest ecosystem function. Given existing data in the territory three indicators were likely to provide information on these criteria: erosion risk (soil stabilization ecosystem service), dominant landscape type (moisture-buffer ecosystem service), and forest fragmentation (ecosystem resilience = sustainability). A decision tree then allows the functioning levels to be characterised based on the concatenation of these three calculated indicators.

This project aims to scale-up the pilot phase by updating data sources and improving the process to create a fast and large-scale tool to deploy the methodology over South Pacific countries with similar concerns.

Therefore the assessment has been carried out on all water drainage basins located above the water catchments supplying the population of New Caledonia, Vanuatu and Wallis and Futuna. In order to scale-up the work at an affordable cost, the methodology relies on free accessible data such as satellites imageries from Landsat and Sentinel Programs, SRTM topography, and World Climate Rainfall Data. Local partners were included in the project in order to inform and provide higher resolution or more recent data when available.

The results of the assessment give an overview of forest functionality at country-scale to contribute to decision-making a national level but a closer analysis of specific watershed results can also improve decision-making and actions at the local level.

AUTHORS

WWF France New-Caledonia Office – The French branch of the international NGO WWF dedicated to environment protection and sustainable development, involved in New Caledonia conservation issues since 1997 with a permanent office in Noumea since 2001.

Contact : Emma DO KHAC – edokhac@wwf.nc

BLUECHAM SAS – An innovative Caledonian company whose core business is to build new solutions to develop greater knowledge and understanding to help protect our planet. Internationally awarded, BLUECHAM SAS is a pioneer in Geospatial Cloud Computing, providing high value added products and systems from earth observation satellites and scientific models. It increases its expertise through R&D projects in cooperation with international space agencies. BLUECHAM's clients are therefore guaranteed of obtaining the best possible data quickly and at the lowest cost.

Contact : Rémi Andreoli – remi.andreoli@bluecham.com

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1 PROJECT DESCRIPTION

1.1 Origin and context

Forests the world over play an essential role as a habitat for the many plants and animals they protect from human activity. In addition to its biodiversity impact, the loss of forest cover is leading to a loss of the ecosystem services enjoyed by communities. Other effects include increased surface run-off, erosion and greater flood damage, while lower infiltration reduces ground water in the dry season and sediment transported into watercourses damages water-supply facilities and diminishes water quality for communities and aquatic life.

This is why the local WWF France branch in New Caledonia, established in 2001, has chosen to highlight the issue and emphasise how urgent it is to protect and restore forests in the South Pacific region. These island groups are often remote and depend heavily on their own agricultural produce to meet their main food needs. The *Freshwater under Threat – Pacific Islands* (UNEP, 2011) report highlights, however, that, against a backdrop of climate change, the islands' dependence on natural rainfall would jeopardise the both their economies and basic subsistence resources. It cites water management as one of the greatest challenges for dealing with the resource's vulnerability. Climate models predict that extreme events like droughts and cyclones will increase and small island countries and territories will need to safeguard their water resources, as, being islands, they will be unable to resort to alternative supplies or solutions that rely on neighbouring countries' resources.

As such, the countries' development sustainability depends on maintaining or restoring forests upstream from drainage basins that provide these key services, but little has been done to monitor forest health in terms of this specific water-resource protection role and optimising management. Committing to do so, however, which can be costly and labour-intensive in terms of practices and management, needs to be based on a sound understanding of the issues and challenges by decision-makers and communities.

The project's objective is, therefore, to assess forest functionality in drainage basins upstream from abstraction points so as to provide information for use by decision-makers and managers to safeguard water resources through the "green infrastructure" provided by forests. The method that has been developed uses freely available geospatial data for producing affordable baseline studies and then setting up large-scale long-term monitoring. It also provides a clear indication of health status using colour coding to represent and rank the functionality of drainage basins and provide guidance for the priority management measures to be adopted.

1.2 Study areas

1.2.1 Vanuatu

The republic of Vanutu is made up of 83 volcanic islands where 286,429 inhabitants were counted in 2016. Six main islands gathered almost 65% of the population: Espiritu Santo, Ambae, Pentecôte, Malekula, Efate and Tanna.

In Vanuatu, the Department of Water Resource, part of the Ministry of Lands and Natural Resources, is in charge of monitoring water supply. It owns a very comprehensive database that counts nearly 5 000 different points of all the population water supply's sources including sources such as rainwater tanks and private wells. This database was used in this study through a partnership with the Vanuatu Government.

The assessment covered the 1 660 actual catchments (superficial waters or groundwater tables), but the surface water abstraction-point sub-category, which is the most relevant to the parameters developed for this study, was extracted for analysis.

1.2.2 New Caledonia

New Caledonia is a special collectivity of France, currently governed under the Nouméa Accord, where 280 000 people live. This population lives in three provinces but the none of the catchments of the Loyalty Islands Province were included in this study as the islands are describe as « low islands » because of their geologic history and have no mountains or rivers. Because of it, water comes from very distinctive boreholes into underground water lens where methodology of our assessment, developed on watersheds, does no act the same way toward water resource.

Collectivity *sui generis,* to which France has progressively transferred most powers, it has for instance its own government. This one includes the Water Service of the Veterinarian, Food and Rural Affairs Direction. The Water Service is responsible of delimiting water protection perimeter above water catchments and advices town councils for the regulation to implement. In addition to the statutorily delineated perimeters, their water catchment database was used to realize the assessment even of water catchments without official protection perimeters delineation.

1.2.3 Wallis and Futuna

Wallis and Futuna is a French territory located in the South Pacific. It is made up of two main islands. Wallis is a low island, which, as for the Loyalty Islands in New Caledonia, means it does not have any mountains and therefore any streams and where population relies on underground water lens.

Therefore, the methodology was implemented only in Futuna Island. Futuna is home of 3 225 people, it counts as a quarter of the global population of Wallis and Futuna. There are six official water catchments, which are monitored by the Service of Environment. Each one on a different stream and so, the assessment has been conducted on six drainage basins.

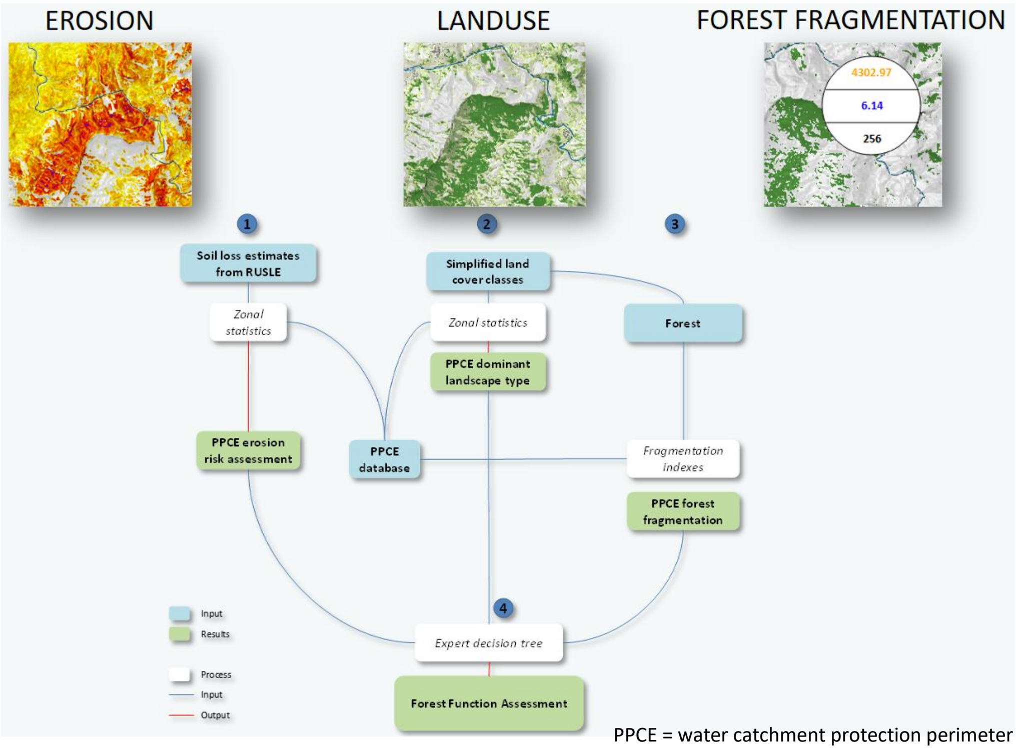
1.3 Methodology, data types and technology

1.3.1 Methodology

Forest management was once a time-consuming pursuit, due to the large areas covered, but it has now been facilitated by satellite imagery and new technology that acquires and processes very large-scale data.

This methodology uses three factors calculated at drainage-basin level and combined through a decision tree to determine the functionality of the vegetation located upstream from collection points.

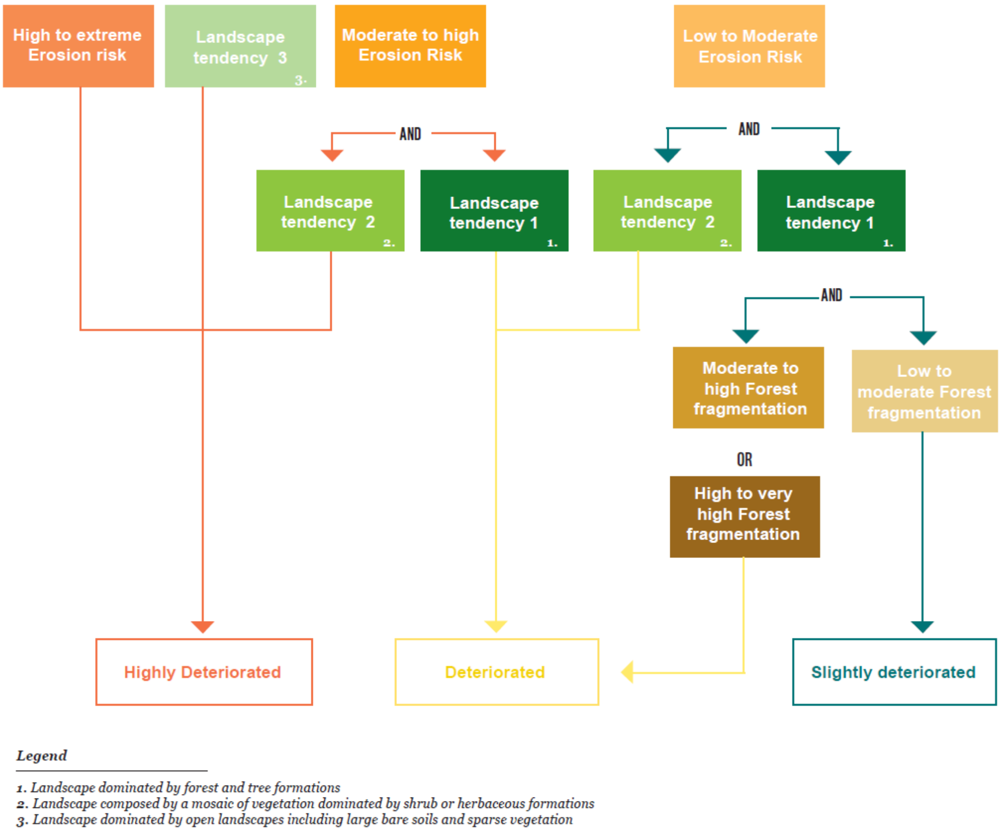
- The erosion level, which needs information such as land cover, rainfall, topography, and geology.
- The landuse, or landscape tendency, which conveys the dominant vegetation stratum in the drainage basin.
- The forest fragmentation, which uses the forest stratum of the land cover and thanks to a merge of two indexes, defines a level of fragmentation.



PPCE = water catchment protection perimeter

Diagrams of the methodology process

The justification of the category and parameters and the thresholds determining the categories' limits of each parameter have been defined through scientific references and the justification.



The decision tree used to determine the forest functionality level of each watershed

1.3.2 Data types and technology

The project's aim was to provide a tool for conducting a uniform large-scale assessment with a subsequent follow-up capacity. The project was therefore based on:

- Free satellite images and public-domain climatology and topography data obtained from global programmes (Landsat-8, Sentinel-2) and World Climate Rainfall Data, or SRTM program, in order to carry out a large-scale uniform assessment suitable for defining management policy for a whole territory; if available and more accurate, topographic local data were also used;
- The co-operation programme between NASA and the European Space Agency to ensure continuity in data acquisition for the coming 30 to 40 years using the Landsat-8 satellite launched in 2013 with a 10-year minimum estimated lifespan and Landsat-9 that is already in the pipeline to replace it, which guarantees long-term monitoring;
- Developing artificial intelligence to speed up and reproduce the process and direct large-scale processing in the cloud-storage system, which reduces costs and significantly accelerates the processes that facilitate scale changes and low-cost deployment in other countries.
- Automating the entire process, in order to facilitate handling by managers.

As there were no recent land cover models, images from the Sentinel-2 and Landsat-8 satellites were used to generate land cover using LandLive, a programme developed by Bluecham. In order to cover all the relevant areas with a 0% cloud objective, multiple satellite coverage was required to reduce cloud cover to a minimum.

The images were put through calibration, pre-processing and derived indicator calculations, such as NDVI, before being fed into the ANN (Artificial Neural Network) process.

The data were reprojected so it could be used in the RGNC 91-93 Lambert conformal conic projection system (EPSG:3163). Similarly, the Sentinel-2 data were acquired with Level 1C processing for standard ground correction (orthorectified and calibrated) based on the same specifications as for Landsat-8 data.

Under the project, New Caledonian land cover can be updated monthly by artificial intelligence (artificial neural network) based on Landsat and Sentinel satellite data which is stored in the LandLive monthly database. The data are 91.32% accurate (kappa coefficient: 0.9031[1]).

The corrected satellite images then undergo a multilevel artificial neural network process to define land-cover classes in an automated manner.

[1] The kappa test measures the agreement between two raters on qualitative category discrimination. There is substantial agreement when the kappa coefficient exceeds 0.61 and excellent agreement over 0.81. The accuracy percentage is provided by a contingency table based on the total number of properly classified pixels out of the sum of pixels tested.

2 Risk mitigation

2.1 Technical risks and experience

BlueCham acquired and processed all satellite imageries for the three countries to create the updated ground occupation modelling which was used for most of the zonal calculations.

Many environment characterization parameters were quickly calculated but there were still some uncertainties related to the vegetation cover and the delineation of drainage basins that needed to be solved before producing any measurable outputs.

2.1.1 Issues in drainage basins delineation

Indeed, a tool to automatically draw drainage basins by spatial analysis using available open-source libraries (QGIS, SAGA, GDAL, GRASS) was developed in order to process the hundreds of water catchment points. Based on one or more outflow points and a surface input data, the tool plots a whole drainage basin flowing to such points. It uses the best Digital Elevation Model available in the country, which could be the SRTM earth topography data and its 30-meters spatial resolution.

In addition, abstraction point coordinates have their own part of imprecision as they could be taken from the field, and so suffer inaccuracies due to GPS flaws or access difficulties, which could lead to mismatches between the abstraction point's true location and the surveyed position.

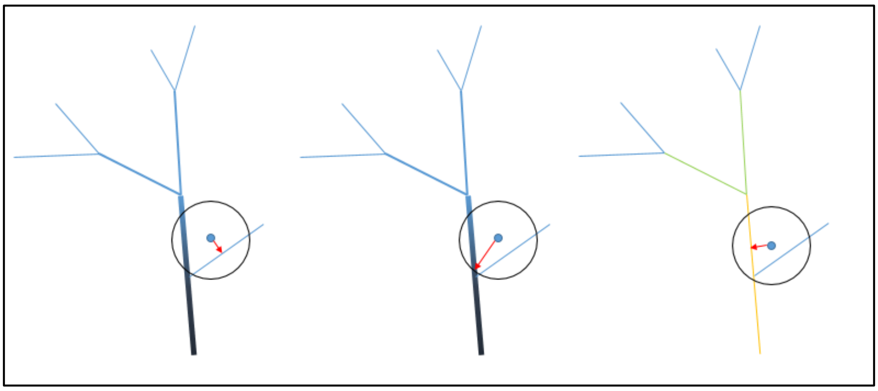
Such slight discrepancies in addition with the DEM imprecision could have created major errors by moving the point outside a flow line and only showing a few adjacent pixels as the "drainage basin". Work was therefore done to correct point locations in order to place them back into flow lines. Several techniques were tested before a satisfactory method was found.

We first checked if small drainage basins were always a mistake by asking local partners and so defining a minimal surface threshold below which a small drainage basin was a confirmed mistake. After comparison with confirmed watersheds, it appeared that 4 000 m² was the limit below which a smatter perimeter smaller was probably an error.

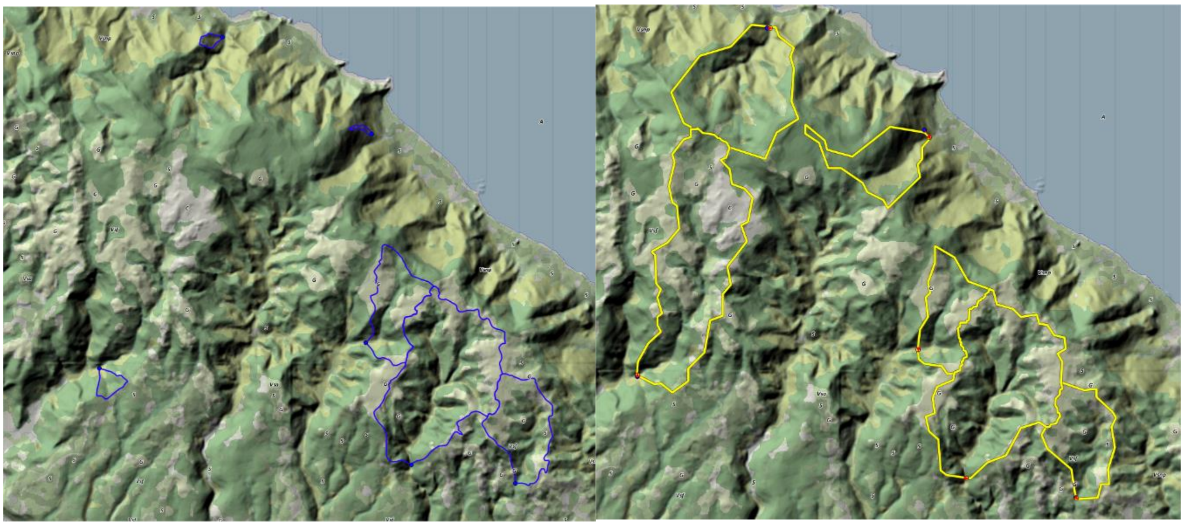
In Futuna, because there were not many errors it could be solved on a case-by-case basis with local partners. But in Vanuatu and New Caledonia, because of the high number of catchment points considered, even a small proportion of errors led to too numerous verifications and corrections. So we had to find a way to automatically fix them and ensure each catchment gets a consistent delineation.

Different methods were tested in order to define one that minimize the number of small watersheds and that provide the more accuracies with confirmed watersheds.

	Method	Method shortcomings
Method 1	Calculate the flow accumulation factor and link the abstraction-point to the nearest stream (searching within a 200 m radius).	Problem: the nearest stream accumulation can be located in "micro-valley" where the abstraction point is unlikely to be situated. In addition, DTM inaccuracies can lead to clearly visible errors in smaller drainage basins.
Method 2	Calculate the stream-accumulation factors and link abstraction-points to the highest stream-accumulation value detected within a 200 m radius.	Stream-accumulation values increase with section length, which may lead much further downstream than necessary.
Method 3	Divide the first stream accumulation into reaches and then allocate Strahler numbers to them. Link abstraction points to the reach with the highest Strahler number within a 150 m radius and not to the highest stream-accumulation pixel.	There could be a bias towards supply points when hydrogeological phenomena dominate the terrain.



Diagrams of the various methods. Method 1 (left), method 2 (centre) and method 3 (right)



Comparison between automatic delineation methods 1 (left) and 2 (right) on Futuna

Despite enhancing drainage-basin definition by linking to the highest Strahler number in a given radius, some drainage basins still appeared inconsistent, often because they were too small. This may have been due to defective abstraction-point location, the DMT grid size not reflecting the terrain sharply enough or the nature of such collection points, particularly "springs" that can emerge upstream from a thalweg, due to dominant hydrogeological effects in terms of the surface, and thus not have a related visible drainage basin above ground.

For the few remaining anomalous drainage basins (< 4000 m²), the choice was made to link them to the elementary drainage basin (that discharged into the sea) that they were a part of.

In short, the shortcomings encountered were:

- Collection points connected to elementary drainage basins: although this option may be appropriate for abstraction points located near the coast, it is less so for inland points;
- Springs where hydrogeological factors dominate locally and are not closely related to the visible features on the surface: linking them to particular drainage basements, however, is a means of indicating potential infiltration areas where it would be advisable to regulate activity based on the pollution hazard to underlying aquifers.
- Repositioning collection points located in very small drainage basins, even though they have been correctly located: when a larger river is located less than 100 m away from the GPS point, it is deemed that the point is erroneously sited and actually located on the larger watercourse. The catchment point could well, however, be located on a smaller tributary. This bias can only be overcome by liaising with the appropriate authorities in relevant territories.

2.1.2 Data processing time

A second issue was the huge volume of data to manage as we had to download and process satellite imageries covering the whole countries (20 000 km² just for New Caledonia).
This was solved by improving the data processing with a continuous updating of ground occupation. But even this could take up to 10 days of continuous processing to cover a country as big as New Caledonia as terasoctets of imageries were processed to deliver the ground occupation.

A solution of improvement of the data process was found by delineating arbitrary sections and updating one section after another continuously.

The first process chain developed was an iterative TDBU (top-down/bottom-up) process. The method had to follow prescribed instructions and needed to be unfrozen by an operator when issues occurred. The process had many drawbacks that could become burdensome when processing data for an area as large as New Caledonia:

- lengthy processing time (5 to 6 months for a 20,000 km² area);
- a semi-automated method requiring lengthy operator hours for corrections;
- remains frozen, if the operator is unable to provide the information; and
- an operator error can affect the entire chain.

As the surface areas to be processed were large and the aim was to develop a tool that could be updated fairly frequently, the process needed to be enhanced. This was done by developing artificial intelligence that would identify reasons for land cover fairly quickly and, above all, autocorrect as experience was acquired. It therefore was more efficient with repetitive tasks.

The operator only intervenes during the training phase to provide reference input data, check that input data (satellite images) are consistent with output data (in this case, land-cover classes) and correct any discrepancies.

However, as much input data as possible need to be supplied, and so reference data has to be obtained from the various jurisdictions, e.g. land cover models, vegetation maps and forest inventory points.

Fresh data can be incorporated and new neural connections developed by a machine-learning process that includes change detection and a priority allocation process by majority vote so that the AI can autocorrect.

Processing was enhanced to speed up satellite imagery analysis for large surface areas and update land cover on a monthly basis. The tool, known as LandLive, was designed to access new images acquired by satellite constellations; and process them to determine land cover.

A first neural network was develop for New Caledonia vegetation and used for Wallis and Futuna. But when it came to Vanuatu, it appeared the IA had difficulties defining ground occupation when it had been first trained on New Caledonia. Therefore, a second neural network especially trained on Vanuatu with the local vegetation maps, was created. The model was very consistent considering the references we had. Because Wallis and Futuna is closer to Vanuatu than to New Caledonia, we chose to try the IA neural network developed in Vanuatu to define Futuna vegetation. It resulted in a better definition of vegetation classes than the previous AI. Because of the amount of data to process, this kind of revision would not have been possible without an AI process.

Developing AI is particularly relevant to the study of environmental issues, because environmental sciences examine areas in their totality and so produce considerable amounts of data; and machine learning is able to manage and is fed by copious amounts of data in order to sort, refine and supply more consistent results.

2.2 Organizational experience and team collaboration

2.2.1 Acquisition of water catchment location

Water catchment location was the first data needed to implement the diagnosis, as our interest is to assess forest functionality in terms of water resource protection, for the waters that are used by local population. When data are not publicly displayed, we depend on our partners' reactivity to provide them.

We got this data very quickly from the New Caledonia Government and the Environment Service of Wallis and Futuna but despite a data sharing agreement with the Water Resource Department of Vanuatu, and the support letter they provided us during our response to the call for proposal, it took us time to collect the water catchment location data.

The Vanuatu consul in New Caledonia had been of a huge support by interceding with the Principal Secretary of the Ministry of Lands and Natural Resources and we ended up getting water catchment location in February 2019. This highlight at this point how crucial it is to have local partners on the spot.
At this time, we were considering other solutions in case we could not get the database such as :

- The use of approximate locations based on other sources such as previous studies and/or points located on rivers close to cities and villages, which could be done if there is much information and/or with a good knowledge of he territory.
- The use of approximate locations based on the GIS flow accumulation.

- Realising the assessment on elementary drainage basins (the whole watershed above each river mouth) even if it would have results in a pessimistic result as the coast is often more deteriorated than the upstream.

The next part would have been to present temporary results to partners hoping it would motivate them to share their data as they would see the result they could obtain. But it would also slow down the delay of realisation by adding a step of initial assessment, business trip and second –final-assessment, which also need time and financial means that were not planned.

2.2.2 Ground occupation modelling and other data acquisition

Local partners were also solicited to confirm the data we managed to get, mainly to ensure there were no more recent or accurate information.

For example, we needed updated references OR vegetation characterization maps at the same or closer date as the satellite imageries, because they were not often available, we needed to have the ground occupation "LandLive" confirmed by partners.

Finally, we had to cope with two issues we did not anticipate.

First a homogeneous result for all drainage basins of a country. Such a result does not enable action priorization, which is one of the main outputs we are expecting from the assessment.

We thought about reviewing the thresholds for the different criteria to adapt to different countries, which would have been complicated because they are based on scientific references, we chose to keep them as they were and instead to have a closer look to the parameters to determine the ones decisive in the diagnosis.

Presented in Wallis and Futuna, it appeared that this outputs were even more useful for forest and land managers as they give a precise information about the priority actions that have to be taken.

Secondly, in these tropical countries, even with satellite imageries acquired every 5 to 16 days, some places of Vanuatu had a systematic cloud cover. The regular acquisition and processing of the imageries and the concatenation of imageries from different dates help to minimize the areas concerned. However for some watersheds the "No Data" qualification of the forest functionality had to be applied.

2.2.3 Organisational experience

If a written agreement can help to support the project as a formal and official document to refer to, the feedback has proven how necessary it is to have involved local partners. We had a very efficient collaboration with the services of New Caledonia and Wallis and Futuna. Concerning Vanuatu, in this project, we were lucky the consul of Vanuatu was very willing to see this study succeed and had frequent opportunities to go and see directly the services concerned to ensure the data we needed were transferred, otherwise we could have not been able to deliver a useful assessment.

A solution we will keep in mind on the future is would be to establish more precisely with the stakeholders every needs we will have, how and when they will be answered. Also we should plan more business trips along the deployment of the project : a starting presentation and outputs expected, one or more intermediate trips to inform of the progress and present temporary results in order to keep the link with our partners, before the final results presentation.

2.3 Replicability and scalability

We chose to produce and make available date disaggregated by geography: we've worked and produced results at country-scale for each country concerned. At first because it was more convenient to work by separated countries, but we kept this way of working as the data available and the results interpretation were more relevant at this scale and because the countries do not have identical tools to use and stock the products of the assessment.

To make the assessment user-friendly for managers, it was automated as much as possible. Using the Qëhnelö hub developed by BlueCham, getting a forest functionality assessment is easy and quick. One just has to input the coordinates of an abstraction point. The data required for the assessment, such as topography, rainfall and satellite images are automatically collected and processed to provide the information to calculate the various factors.

The main challenge of this project was to develop a quick and efficient way to collect and process the data needed to create an accurate land occupation map and erosion modelling. This was done using Artifical Intelligence that accelerates the process (for a country the size of New Caledonia, it now takes 4-5 days instead of months). In addition, all processing occurs on a cloud, making it faster and available from any country.

This time reducing technologies contribute to lower the cost of the process, the assessment can then be more easily replicated over the years to allow progress monitoring and achievement of conservation actions implemented.

Today the assessment methodology can be deployed and/or updated in any country. Different neural networks can be quickly developed and are interesting to compensate for the diversity of vegetation formation between countries that a single network could not grasp.

Erosion phenomenon calculation needs to be adjust to the local parameters of the country. The methodology tries to get most of them directly from the global public sources, but a closer look to the data available at country scale can help to create more accurate modelling.

For example, in the erosion model using Wischmeier and Smith (1978) RUSLE equation (A = R.K.L.S.C.P), the K factor (soil erodibility) can be estimated using the e EPIC method as per the following Sharpley & Williams (1990) formula based on soil data for the 0-5 cm ISRIC soil database standard depth. But in New Caledonia, a specific work has adapted Stone and Hilborn (2011) factors to New Caledonia in order to determine soil-loss potential values that would make the erosion model more accurate.

As mentioned above, the cloud cover in tropical countries can be so constant that it can be impossible to determine the ground occupation in some places. In the reduced cases it occurs, an updated ground modelling is impossible to create through satellite imageries, however a manual assessment can be considered using any other vegetation map providing data over the watersheds concerned.

3 Conclusions

The project has enable the assessment of forest functionality to provide the critical ecosystem services that participate to improve water security.

As previously presented, the development and optimization of the assessment methodology thus developed enabled the production of land use models and erosion models quickly at the scale of a country and homogeneous at the scale of the region. This increase in speed allows a lower use of servers and thus a reduced cost of implementation compared to traditional methods, which facilitates the updating of these models. In addition to the forest functionality status which is a new data for the countries concerned, the project has made it possible to update data that are obsolete or even absent in some countries, thus giving information that has not been available before.

The disaggregation by people characteristics (sex, age, disability, gender) is irrelevant in our project, however we produced and made available data disaggregated by geography at country scale. At first it was for convenience matter as it was easier to work one country after another given the fact our partners didn't provide information at the same time. But at the end of the project, since each country has its own use and data access permission, and different working scale, related to country size, it was relevant to keep each country's results distinct from each other.

The results for each country and the deliverables are hosted in the national hubs created by BlueCham for New-Caledonia and Vanuatu. As the FLOW assessment has also be done on two rivers watershed of Fiji and because BlueCham have already worked with them on a different topic, a Fijian hub has also been deployed. By creating an account on the following websites, it enable to access the project related information. Since they are national country-hubs allowing crossing data, both private and public, free and paid, they are secure and access needs to be approved.

http://nc.qehnelo.net
http://vanuatu.qehnelo.net
http://fiji.qehnelo.net

The public documents in French version (the methodology full report and the project summary) can also be found on the WWF France website, in the New Caledonia Rain Forest page:
https://www.wwf.fr/projets/proteger-et-restaurer-les-forets-humides-de-nouvelle-caledonie

Sharing results and methodology to the countries and territories involved a discussion to facilitate its appropriation by local governments. Thereby, in New Caledonia, the results are currently used to determine priority watersheds for actions in the *Shared Water Policy* formulated by the Government. In Wallis and Futuna, the results are being used to drive actions to implement in the framework of the *PROTEGE* Program. The Environment Department also wishes to extend the assessment over the informal water catchments of Futuna Island. In Vanuatu, the results might be included in the next *State of Environment* report the Environment Department is about to provide. Thanks to a complementary funding, two watersheds of Fiji were also assessed through the same methodology.

Finally, as we had the opportunity to attend the 29th SPREP (Secretariat of the Pacific Regional Environment Programme) in early September 2019. The Environmental Monitoring and Governance Programme was very interested in the possibilities to spread out the assessment over the others countries of the Pacific region. Therefore, we are keeping in touch with them to give them all information and support to integrated more countries in a global assessment to improve both forest and water managements in order to highlight nature-based solutions as a way to cope with inevitable climate perturbations in the decades to come.

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The New-Caledonia office in numbers

2001

opening year of the WWF France New-Caledonia office

3

partner territories included in the forest assessment project

+ than 600

volunteers involved in New-Caledonia

+ than 100 000

trees planted in order to restore the New-Caledonian forest

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WWF France, 35-37 rue Baudin, 93310 Le Pré-Saint-Gervais

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