Negotiation-support toolkit for learning landscapes

Editors
MEINE VAN NOORDWIJK
BETHA LUSIANA
BERIA LEIMONA
SONYA DEWI
DIAH WULANDARI

WORLD AGROFORESTRY CENTRE
Southeast Asia Regional Program

Tanika L and van Noordwijk M. 2013. Flow persistence (FlowPer). *In:* van Noordwijk M, Lusiana B, Leimona B, Dewi S, Wulandari D (eds). *Negotiation-support toolkit for learning landscapes*. Bogor, Indonesia. World Agroforestry Centre (ICRAF) Southeast Asia Regional Program. P.171-173.

30 | Flow persistence (FlowPer)

Lisa Tanika and Meine van Noordwijk

The Flow Persistence (FlowPer) model produces an indicator that summarizes the relationship between rainfall and river flow and current (today) with previous (yesterday) river flow. The flow persistence value can indicate how well the watershed is buffering rainfall and thus avoiding flash floods. Flow persistence values of above 0.8 may reflect good watershed conditions, while values below 0.4 indicate a poorly buffered watershed. The values can be used as a basis for conditional environmental services' rewards.

Introduction

Analysis of watershed functions deals with complex factors that influence processes and patterns in the landscape that ultimately translate a temporal pattern of rainfall into a temporal pattern of stream flow, which aggregates to become a river. The Flow Persistence (FlowPer) model uses information from a time series of river-flow data to deduce what may happen upstream in the absence of knowledge on 'anthropogenic' intervention that could have occurred as well as the geological and climatic background.

The FlowPer model provides a parsimonious null-model that is based on temporal autocorrelation or an empirical 'flow persistence' in the river-flow data. The basic form is a recursive relationship between river flow (Q) on subsequent days:

$$Q_{t+1} = f_p \, Q_t + Q_{add}$$

where Q_t and Q_{t+1} represent the river flow on subsequent days, f_p is the flow persistence value ([0< f_p <1]) and Q_{add} is a random variate that reflects inputs from recent rainfall.

Q_{add} and f_p are related, as $\Sigma\, Q_{add\,i} = (1 - f_p)\, \Sigma Q$. Thus, if $f_p = 1$, $Q_{add} = 0$ and river flow is constant, regardless of rainfall (the ideally buffered system. If $f_p = 0$ there is no relation between river flow on subsequent days and the river is extremely 'flashy', alternating between high and low flows without temporal predictability within the frequency distribution of Q_{add}.

The term $Q_{add,i}$ can be described as a statistical distribution with a probability of a non-zero value, a mean and a measure of variance, plus two parameters that describe a seasonal pattern (peak and shape of the distribution, for example, Weibull[1]).

If we partition the total flow Q_{tot} into water flow by three pathways (surface runoff, interflow and groundwater flow), we can obtain $Q_{tot} = Q_{runoff} + Q_{interflow} + Q_{gwflow}$. Each type of flow pathway will typically have a different flow persistence, $f_{p'runoff}$, $f_{p'interflow}$ and $f_{p'gwflow,}$ respectively.

---

[1] Weibull distribution is a continuous probability distribution (in probability theory and statistics)

$$Q_{tot,t+1} = (f_{p',runoff}(Q_{runoff,t}/Q_{tot,t}) + f_{p',interflow}(Q_{interflow,t}/Q_{tot,t}) + f_{p',gwflow}(Q_{gwflow,t}/Q_{tot,t}))Q_{tot,t} + Q_{add,t}$$

As we can expect values for $f_{p',runoff}$, $f_{p',interflow}$ and $f_{p',gwflow}$ of about 0, 0.5 and close to 1, respectively, we can interpret the relative contributions of the three flow pathways from the overall f_p value.

Objectives

1. FlowPer provides indicators of how well a watershed is provisioning the stability of river flow.
2. FlowPer serves as a parsimonious (parameter-sparse) null model that allows quantification of the increments in model prediction that is achieved with spatially explicit models.

Steps

1. Gather daily river-flow data and rainfall data in addition to calculating flow persistence value (f_p).
2. Calculate f_p and Q_{Add} value using 'Preparation Input FlowPer.xls'.
3. Assess the hydrological function based on f_p and rainfall data.
4. Run FlowPer to predict other daily river discharges based on f_p value.

Case study: Bialo watershed

Bialo Bayang-Bayang discharge station is located in upper Bialo watershed, South Sulawesi, Indonesia. This station covers 5020 hectares, 44.9% of Bialo watershed, which is mainly dominated by forest. However, from during 1989 to 2009, the forest area (both primary and secondary) in Bialo watershed decreased from 49 to 36%. The area was largely converted to clove agroforestry.

We analyzed the buffering capacity of the Upper Bialo watershed using FlowPer. The purpose was to make a quick assessment of the watershed condition based on river discharge behaviour. The result showed that the flow persistence values tended to increase with an average value of 0.8, reflecting good watershed conditions (Figure 30.1).

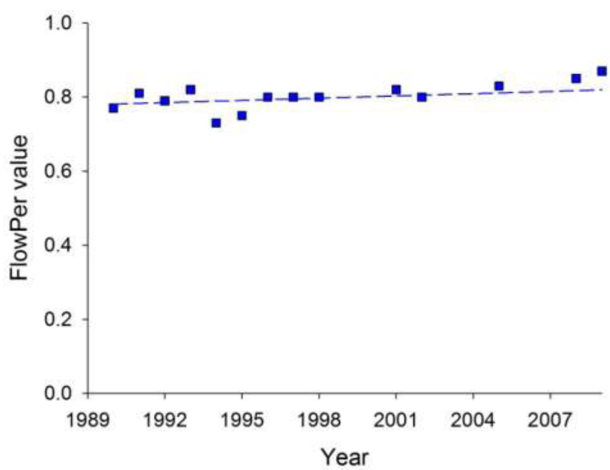

Figure 30.1. FlowPer value in Bialo Bayang-Bayang station over a 21-year simulation

The example of river discharge prediction using FlowPer is shown in Figure 30.2. The generation of this river discharge is based on f_p value 0.75 and Q_{Add} 0.4. The model evaluation between observed and simulated shows that both river discharges has a daily correlation 0.49 and 0.86 for monthly correlation. It means that the FlowPer can predict river discharge using a simple parameterization.

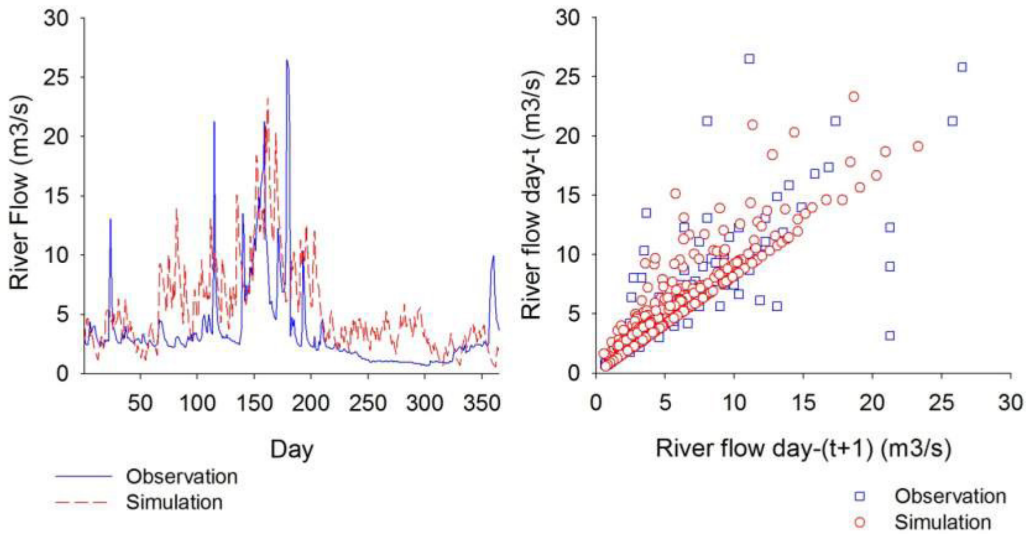

Figure 30.2. Example of the type of 'fit' that can be achieved for the six parameter null-model. This simulation used Upper Bialo watershed data for 1993

Key reference

Van Noordwijk M, Widodo RH, Farida A, Suyamto D, Lusiana B, Tanika L, Khasanah N. 2011. GenRiver and FlowPer: Generic River and Flow Persistence models. User manual version 2.0. Bogor, Indonesia: World Agroforestry Centre (ICRAF) Southeast Asia Regional Program. http://www.worldagroforestry.org/sea/publication?do=view_pub_detail&pub_no=MN0048-11.

The landscape scale is a meeting point for bottom–up local initiatives to secure and improve livelihoods from agriculture, agroforestry and forest management, and top–down concerns and incentives related to planetary boundaries to human resource use.

Sustainable development goals require a substantial change of direction from the past when economic growth was usually accompanied by environmental degradation, with the increase of atmospheric greenhouse gasses as a symptom, but also as an issue that needs to be managed as such.

In landscapes around the world, active learning takes place with experiments that involve changes in technology, farming systems, value chains, livelihoods' strategies and institutions. An overarching hypothesis that is being tested is:

> Investment in institutionalising rewards for the environmental services that are provided by multifunctional landscapes with trees is a cost-effective and fair way to reduce vulnerability of rural livelihoods to climate change and to avoid larger costs of specific 'adaptation' while enhancing carbon stocks in the landscape.

Such changes can't come overnight. A complex process of negotiations among stakeholders is usually needed. The divergence of knowledge and claims to knowledge is a major hurdle in the negotiation process.

The collection of tools—methods, approaches and computer models—presented here was shaped by over a decade of involvement in supporting such negotiations in landscapes where a lot is at stake. The tools are meant to support further learning and effectively sharing experience towards smarter landscape management.

World Agroforestry Centre

ASB Partnership for the Tropical Forest Margins

AARD

Federal Ministry for Economic Cooperation and Development

Norad

IFAD
Enabling poor rural people to overcome poverty

CGIAR
Research Program on Forests, Trees, and Agroforestry