



# Modelling Stormwater Runoff Changes Induced by Ground-Mounted Photovoltaic Solar Parks: A Conceptualization in EPA-SWMM

Aurora Gullotta<sup>1</sup> · Tagele Mossie Aschale<sup>1,2</sup> · David J. Peres<sup>1</sup> · Guido Sciuto<sup>3</sup> · Antonino Cancelliere<sup>1</sup>

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## Abstract

A modelling framework for the simulation of stormwater runoff in ground-mounted photovoltaic solar parks is proposed. Elements in the solar park and their mutual interactions during precipitation events are conceptualized in EPA-SWMM. We demonstrate the potential of the framework by exploring how different factors influence runoff formation. Specifically, we carry out simulations for different sizes of the installation, soil types and input hyetographs. We also show the effect of ground cover, by changing the surface roughness. Outflow discharge from the park is compared to that from a reference catchment to evaluate variations of peak flow and runoff volume. Results highlight no practical changes in runoff in the short term after installation. However, in the long term, modifications in soil cover may lead to some potential increase of runoff. For instance, increments of the peak flow from the solar park up to 21% and 35% are obtained for roughness coefficient reductions of 10% and 20%, respectively. The proposed modelling approach can be beneficial for studying hydrological impacts of solar parks and thus for planning measures for their mitigation.

**Keywords** Environmental impacts · Renewable energy · Sustainable water resources management · Peak flow · EPA-SWMM

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✉ Aurora Gullotta  
aurora.gullotta@unict.it

<sup>1</sup> Department of Civil Engineering and Architecture, University of Catania, Via A. Doria 6, Catania 95125, Italy

<sup>2</sup> Department of Geography and Environmental Studies, Debre Markos University, Debre Markos P.O. Box 269, Ethiopia

<sup>3</sup> Ambiens Srl, Via Roma, 44, Valguarnera Caropepe, Enna 94019, Italy

## 1 Introduction

The continuous growth of global population causes increasing concerns on food, water, and energy sectors (Sarkodie and Owusu 2020; Makaronidou 2020). The energy generation processes are facing major challenges such as sustainability, cost, security, and market price fluctuations (Almomani 2020; Ebhota and Jen 2020). In addition, the increase in environmental awareness and the application of more stringent discharge regulations has directed the scientific community to work on developing alternative, sustainable, and renewable energy sources (Ahmad et al. 2020; Tawalbeh et al. 2021; Yavari et al. 2022; Bertsiou and Baltas 2022; Loucks 2023).

Among all the renewable energy sources, solar photovoltaic (PV) is one of the most widespread in the world (Ravi et al. 2014; Armstrong et al. 2016; Barron-Gafford et al. 2016; Hassanpour Adeg et al. 2018). Although solar energy is universally recognised as environmentally friendly energy source, impacts on surface hydrology of large parks have not been comprehensively addressed in literature (Turney and Fthenakis 2011; Pisinaras et al. 2014; Yavari et al. 2022). With growing concern over the impact of land use changes on stormwater runoff, the construction of large-scale solar power plants may face obstacles in the future unless appropriate quantification of this impact is addressed and proper measures are taken to mitigate potential increment of flow peak and volume discharge (Turney and Fthenakis 2011).

Assessment of runoff generation in PV solar parks can be carried out by modelling-based approaches, that have the advantage, with respect to purely experimental studies, to allow the investigation of the influence of different hydrological conditions (Yavari et al. 2022). For instance, among the studies based on such approach, Barnard et al. (2017) set up a 1D/2D model by coupling Flo-2D and HEC-HMS to simulate stormwater runoff at three selected solar PV installations in west Texas. However, no comparison with the pre-installation scenario has been carried out thus preventing the possibility to evaluate the impacts on stormwater runoff induced by the presence of solar panels. HEC-HMS was also used to study hydrologic dynamics in a Nevada solar farm (Edalat 2017). The simulations showed that runoff volume always increases after solar panels installation. However, one major limitation of this study was that solar panels were represented as an impervious surface on the ground, and simulation of the infiltration process could not be permitted under the panels, as it would indeed occur at an actual site. Thus, this approach likely overestimates runoff volume. The Soil & Water Assessment Tool (SWAT) was used for assessing the impact of PV solar parks on watershed hydrology by Pisinaras et al. (2014). Solar parks installation was represented by implementing in the model soil physical properties/ground cover changes, curve number increases associated with imperviousness, and reduced solar radiation. In this case, model limitations consist in the fact that the dynamics of the runoff formation in the solar park are not explicitly taken into account. Other researchers developed a custom-built model for representing runoff in solar parks (Cook and McCuen 2013). The results indicated that the addition of solar panels over a grassy field does not change the volume of runoff, the peak discharge, nor time to peak. More recently, Wang and Gao (2023) conducted experiments at the plot-scale to investigate impacts of PV panels on rainfall-runoff and soil erosion processes. Results showed that runoff volume, peak flow discharge rate and overland flow velocity are not remarkably impacted by the presence of PV panels. However, further investigations are needed to transfer the obtained results at the plot scale to a real scale solar park.

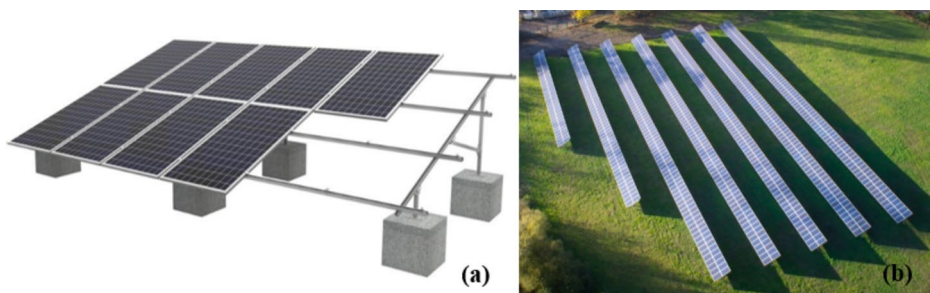
Analysis of the literature on the topic highlights a research gap consisting in the lack of a comprehensive tool for the assessment of the impacts of real-scale solar parks on stormwater runoff, by taking into account the hydrological processes occurring within the park and all the variables affecting the park response to precipitation events. In this paper, with the aim of overcoming many of the mentioned limitations within previous studies, we propose a novel conceptualization of PV power parks response to precipitation events capitalizing on the use of the free and open-source Storm Water Management Model (SWMM) (Rossman 2015). The conceptualization allows to take into account the complex hydrological process occurring in the solar parks during precipitation events and to assess how the process of runoff in the park is affected by the extension of the PV installation, soil properties and the characteristics of the rainfall events. Moreover, effects of long term changes in roughness surface induced by the presence of the panels can be taken into account in the analysis. We demonstrate the potentialities of the proposed approach considering a layout of the PV installation (panels size and inclination) as well as characteristics of the precipitation events that are encountered in Sicily (south Italy).

## 2 Conceptual Model

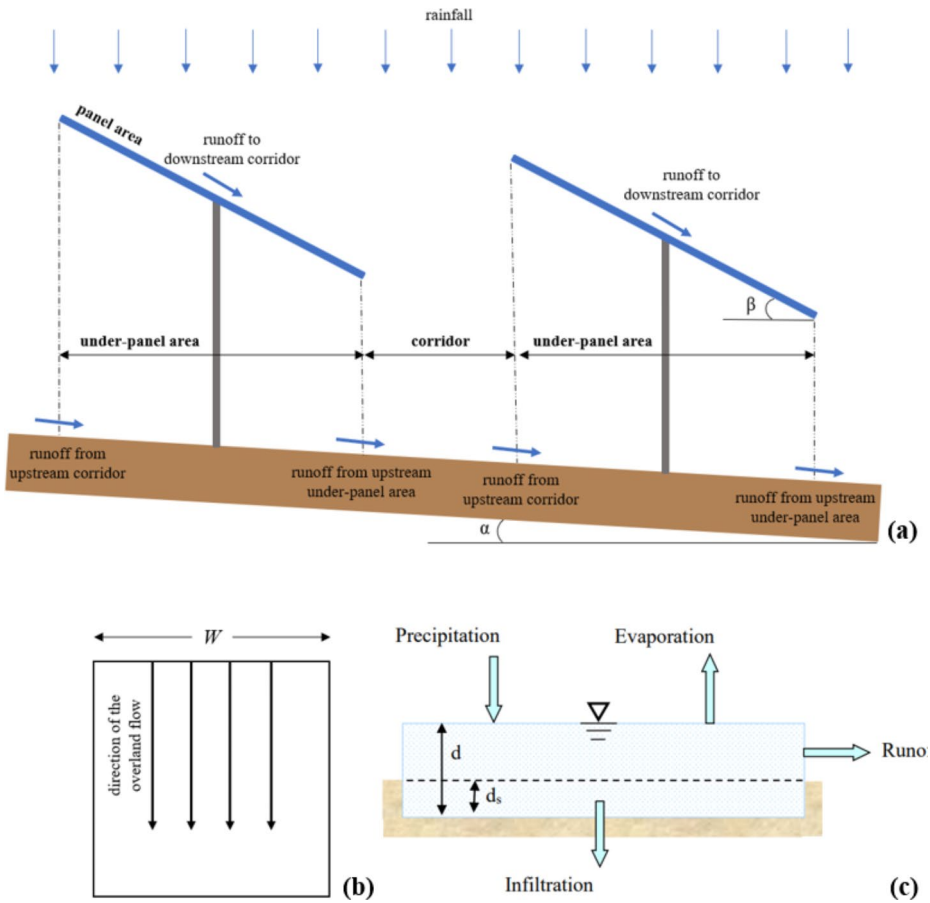
### 2.1 Water Paths in Ground-Mounted PV Solar Parks

Panels in ground-mounted PV solar parks are usually placed on a metal frame that is mounted on the ground to hold the panels at a fixed angle. The frame usually can hold more than one panel rows (usually from 2 to 4) in the vertical direction (Fig. 1a). Panels on the metal frame are then arranged in rows of different length (Fig. 1b). Panels rows are separated by corridors to allow for maintenance operations as well as the movement of vehicles.

The presence of the panels rows in the solar park induces a redistribution of the rainfall approaching the ground as compared to the pre-installation scenario. Based on the input/output during precipitation events, three different parts of the PV installation can be distinguished: the panel area, the under-panel area and the corridor (Fig. 2a). The water fallen on the impervious panels surface is rapidly drained towards the corridor immediately downstream the panels row. In this way, each corridor receives both the direct rainfall and the runoff from the impervious surface of the panel. The under-panel area, instead, is not directly reached by the rainfall but it can receive the runoff from the upstream corridor and let the



**Fig. 1** (a) metal frame to hold panels and (b) panels arranged in rows in typical ground-mounted solar PV parks



**Fig. 2** (a) water paths in typical ground-mounted solar PV parks, (b) subcatchment conceptualization and (c) scheme of the nonlinear reservoir model in EPA-SWMM.

water infiltrate. Runoff from the under-panel area is collected by the corridor immediately downstream the panels row.

Water infiltration occurs both in the under-panel area and in the corridor. However, the corridor is likely to reach saturated conditions earlier as compared to the under-panel area because of the concentration of three different contributions (rainfall, runoff from panel area, runoff from the upstream under-panel area).

It is worth noting that in the adopted scheme for water paths showed in Fig. 2a, the same flow direction is assumed for the ground and for the panels rows. Actually, direction of the PV panels is generally set with the aim to maximize the exposure of the panels to solar radiation, regardless of the ground slope direction. In case of different flow directions for the ground and for the panels rows, water paths within the PV installation are not the same of those described in this section and have to be investigated case by case. As an example, if

panels rows and are placed along the main ground flow direction, runoff from the corridors would not be routed to the under-panel areas, thus, practically, reducing the available areas for infiltration within the park.

## 2.2 Modelling Ground Mounted PV Solar Parks with EPA-SWMM

The Storm Water Management Model (SWMM) is a free and open-source software developed by the United States Environmental Protection Agency (US-EPA). The release n. 5.1 of the software was used in this study (Rossman 2015).

SWMM is a dynamic rainfall-runoff model used for single event or continuous simulation. The software is widely used in literature and was recently applied for estimation of runoff from urban areas also in presence of low impact development (Ferrans and Temprano 2022; Hashemi and Mahjouri 2022; Nazari et al. 2023; Zhuang and Lu, 2023) and for optimization problems in water distribution systems (Gullotta et al. 2021a, b). The runoff component of SWMM operates on a collection of subcatchment areas that receive precipitation and generate runoff, after computation of water losses. The software conceptualizes subcatchments as rectangular surfaces with uniform slope  $S$  and width  $W$  [m] (Fig. 2b). Overland flow is generated by modelling the subcatchment as a nonlinear reservoir (Chen and Shubinski 1971), as sketched in Fig. 2c.

In particular, the subcatchment experiences inflow from precipitation and losses from evaporation and infiltration. The net difference ponds on the subcatchment surface with a depth  $d$  [m] (Fig. 2c). A part of the ponded depth,  $d_s$  [m], can fill the depression storage, while the remaining part ( $d-d_s$ ) become runoff outflow  $q$ . From conservation of mass, the net change in depth  $d$  per unit of time  $t$  can be expressed as (Rossman 2016):

$$\frac{\partial d}{\partial t} = i - e - f - q \quad (1)$$

where  $i$ ,  $e$ ,  $f$  and  $q$  are the flow rates per unit of area [ $\text{m}^3/\text{s}/\text{m}^2$ ] for precipitation, evaporation, infiltration and runoff, respectively.

Flow rate is calculated by using the Manning equation for an open rectangular channel of width  $W$ , slope  $S$  and a given roughness coefficient  $n$  [ $\text{s}/\text{m}^{1/3}$ ]. Infiltration losses can be computed within the software by using different infiltration models. For the conceptualization proposed in this paper, Green Ampt method is used to model infiltration in pervious subcatchments (Green and Ampt 1911). Water losses for evaporation are not taken into account in this work since only simulations of single events have been carried out so that evaporation process can be neglected.

In order to reproduce water paths described at Sect. 2.1, panel areas, under-panel areas and corridors are modelled in EPA-SWMM as rectangular subcatchments (placed in series) with different input/output settings. In particular, precipitation input is set up for subcatchments representing panel areas and corridors but not for those representing under-panel areas. Moreover, runoff from each subcatchment is discharged to downstream subcatchments according to the flow paths showed in Fig. 2 (i.e., panel area to corridor, corridor to under-panel area and under-panel area to corridor). Runoff from the most downstream subcatchment is assumed to be the outflow from the solar park. Finally, infiltration is allowed for all the subcatchments except for those representing panel areas.

### 3 Modelling Scheme

#### 3.1 PV Power Plant Hydrological Characteristics

For the demonstration carried out in this study, we have considered the following characteristics of the subcatchments. Panel areas in the PV park are modelled as totally impervious subcatchments with inclination  $\beta=30^\circ$  to the horizontal (Fig. 2a). This inclination is common for PV installations at the latitude of south Italy. A metal frame holding 2 panels in the vertical direction is supposed, with single panel having a length of 2.38 m and a width of 1.3 m, which are within typical dimensions for industrial panels used in solar parks. Panels' surface is usually made of very smooth glass; therefore,  $n=0.007$  is associated to subcatchments representing panel areas. Corridors and under-panel areas are modelled as totally pervious subcatchments. Length of corridors is usually optimized to minimize shadows effects between two panels rows. However, a minimum distance (range 2.5-3 m) between two panels rows has to be guaranteed to allow for the safe moving of maintenance vehicles. In the model, a length of 2.7 m is associated to the corridors, while the length of the under-panel areas can be derived projecting the length of 2 panels to the horizontal (i.e., 4.12 m). Ground slope in the solar park is set equal to 1% (Palmer et al. 2019).

Besides, a reference catchment with the same extension of the park is modelled. In order to maintain the same modelling scale and enable comparison, the reference catchment is divided in subcatchments equivalent to the corridors and the under-panel areas (same area and ground slope). In this case, all the subcatchments in the reference have the precipitation input and allow for infiltration. Moreover, each of these subcatchments discharges its runoff to the subcatchment immediately downstream. Runoff from the most downstream subcatchment is assumed to be the outflow from the reference catchment and used for comparison with runoff from the solar park. Ground cover for the reference catchment is assumed to be grass, by setting a roughness Manning coefficient  $n=0.15$  (McCuen et al. 1996).

Since, as already stated, we are assuming that direction of flow coincides with the slope of the panels, all terms in Eq. (1) are linear functions of the subcatchment width  $W$  and therefore all simulations are carried out by setting  $W=1$  m for all the subcatchments in the PV solar park and in the reference catchment. Results obtained (in terms of runoff per unit of width) can then be scaled for any size of the solar park by simply multiplying for the actual width of the installation.

Single events simulations are run in EPA-SWMM setting a time step of 1 s. In the following sections, variables and parameters potentially affecting the runoff from the PV solar park are discussed.

##### 3.1.1 PV configurations

Simulations have been carried out considering three different configurations of the solar park. In particular, sequences of 10, 20 and 40 panels rows are modelled to represent small, medium and large PV installations, respectively. The three selected extensions (extension 1, 2 and 3 in the following of the paper) correspond to total areas per unit of width of the installation of about 70, 135 and 270 square meters.

### 3.1.2 Soil type

To test the impacts of soil texture on runoff from solar parks, simulations have been performed for three different soil types. In particular, Green Ampt infiltration parameters for loamy sand, clay loam and silty clay soil type (soil type A, B and C in the following of the paper) have been associated to subcatchments in the software, thus going from more pervious to less pervious soil (Rawls et al. 1983). In each simulation, the same soil type is assumed for the solar park and the reference catchment.

Fraction of soil porosity that is initially dry (i.e., initial deficit) has to be specified in the software. Initial deficit equal to zero is representative of saturated conditions. An initial deficit equal to the difference between the soil porosity (saturated soil) and the field capacity has been set up. The chosen initial condition for soil moisture is typical of soils in the winter season at the beginning of a precipitation event with a sufficient antecedent dry weather period.

### 3.1.3 Storm characteristics

Precipitation events given as input for the simulations are derived from the Depth-Duration-Frequency (DDF) curves of the rain gage of Agira in Sicily (south Italy). Values of parameters of the DDF curves, in the power law form  $h = at^n$ , of the selected rain gage correspond to the median of 139 stations in Sicily (Failla 2022). Events of 5, 20 and 50-years return period (RP) are simulated. Parameters  $a$  of the DDF curves are equal to 34.72, 49.02 and 58.09 for RP of 5, 20 and 50 years, respectively, while corresponding exponents  $n$  are equal to 0.339, 0.354 and 0.360.

Besides magnitude, influence of duration and temporal distribution of the precipitation event is investigated. First, constant intensity rainfall events with duration of 10 min, 1 and 3 h and rainfall intensity derived from the DDF curves are given as input to the model. Then, hyetographs of 1 and 3 h durations derived from the Chicago method (Keifer and Chu, 1957) are considered. For the construction of the Chicago hyetographs, a time step of 10 min is adopted and the highest peak of precipitation height is placed almost in the middle (3rd time step for the 1-hour hyetograph and 9th time step for the 3-hour hyetograph). When deriving precipitation heights for sub-hourly durations, exponent of the DDF curve is changed in 0.5 (Engman and Hershfield 1981).

### 3.1.4 Ground Cover

Different ground covers have been assumed, related to short and long term conditions after PV installation. In the short term after installation of the PV park, no significant changes in ground cover are expected with the respect to the pre-installation scenario. In the long term, operation of the PV solar parks involves the use of maintenance vehicles that could affect the soil properties in the area between panel rows - in terms of compaction and reduced hydraulic conductivity (Pisinaras et al. 2014; Choi et al. 2020). Moreover, the area under the panel rows may experience, in time, a lower vegetation growth rate as compared to the space between rows because of the reduced amount of photosynthetic active radiation (Armstrong et al. 2016; Jahanfar et al. 2019). Hence, changes in surface roughness are taken into account here. In particular, the presence of the panels rows together with the mainte-



nance activities of the park usually lead to a reduction of the surface roughness. Therefore, simulations have been run by assuming the same roughness coefficient of the reference catchment for corridors and under-panel areas, thus allowing evaluation of the runoff from the park in the short term after installation (short-term condition). Secondly, progressive reduction (by 10% and 20%) of the original roughness coefficient is supposed for corridors and under-panel areas in order to evaluate the impacts on runoff of long term changes in surface roughness induced by the presence of the solar park (long-term condition).

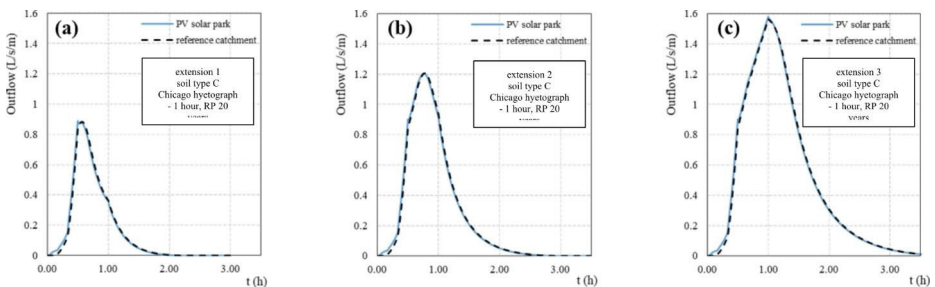
## 4 Results and Discussion

A total of 135 simulations have been run for the short-term condition by combining all the model parameters and precipitation inputs described in the methodological section.

Figures from 3 to 5 compares the outflows from the PV solar park and from the reference catchment as resulting from 9 simulations.

In order to assess the impact on runoff of the park extension, Figs. 3a, 3b and 3c show outflows from parks of extension 1, 2 and 3, respectively, and soil type C. In the 3 simulations, the precipitation input is a Chicago hyetograph of 1 hour duration and 20-years RP.

For fixed soil type and precipitation input, increments of the park extension result in increments of the peak flow and of the total runoff volume (Fig. 3a, b and c). In particular, peak flow per unit of width increases by 33% each time the area of the solar park is doubled (from extension 1 to 2 and from extension 2 to 3), due to the non-linearity of the processes involved in the runoff formation. The outflow curve from the solar park follows the corresponding curve from the reference catchment both in the rising and in the recession limb of the hydrograph, regardless of the park extension. Minimal differences between the two outflow curves can be observed at the beginning of the precipitation event (first 20 min), with values of the outflow from the solar park slightly higher than those from the reference catchment. Analysis of the simulations output allows to ascribe this behaviour to the most downstream part of the solar park. Indeed, the generic corridor in the solar park receives in input the direct rainfall and the runoff from the panel area. The two contributions are practically simultaneous as the time of concentration of the panel area is in the order of a few seconds. Therefore, for a given soil infiltration capacity, the corridor generates excess of runoff with the respect to the portion of the reference catchment placed at an equal distance from the outlet. This excess of runoff can be later infiltrated in downstream under-panel areas and



**Fig. 3** Outflows from the PV solar park and from the reference catchment for different park extensions (short-term condition)



corridors. However, the most downstream corridor delivers the runoff directly to the outlet thus anticipating the time for the beginning of the runoff as observed in Fig. 3a, b and c.

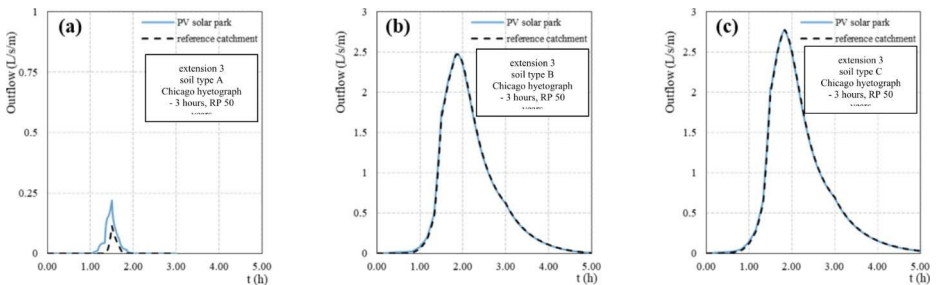
Influence of the soil type on the runoff from the solar park is shown in Figs. 4a, 4b and 4c, referring to simulations run for solar park of same extension (3) and precipitation input (Chicago hyetograph 3-hours duration, 50-years RP) but different soil type (A, B and C, respectively).

For fixed solar park extension and precipitation input, changing from sandy to clay soils results in increased peaks flow and total runoff volumes, due to the reduction in infiltration capacity (Fig. 4a, b and c). In particular, peaks flow from solar park results equal to 0.2, 2.5 and 2.8 L/s per unit of width for soil type A, B and C, respectively. Peak flow and total runoff volume from the solar park are greater than the corresponding values from the reference catchment only for soil type A (Fig. 4a). Indeed, in soil with high infiltration capacity, almost all the precipitation is infiltrated. In this case, excess of runoff from the corridor immediately upstream the outlet (with no other downstream under-panel areas and corridors available for infiltration) assumes a greater relative weight. However, the increment of peak flow and total runoff showed in Fig. 4a is not significant in absolute terms (peak flow for unit of width less than 0.25 L/s). The same conclusion can be drawn for other simulations with soil type A in which differences in the outflows from the solar park and from the reference catchment are observed.

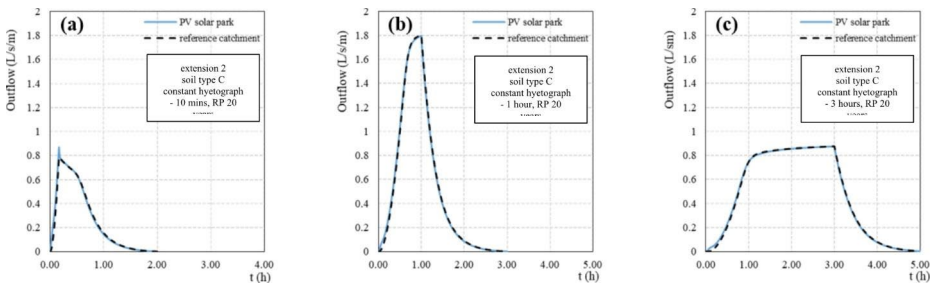
Finally, Figs. 5a, 5b and 5c show outflows from solar parks of extension 2 and soil type C for constant precipitation input of durations 10 minutes, 1 hour and 3 hours, respectively, and 20-years RP.

For fixed solar park extension and soil type, outflow from the solar park is equal to that from the reference catchment (in terms of peak flow and total runoff volume) regardless of the duration of the precipitation event as shown in Fig. 5a, b and c.

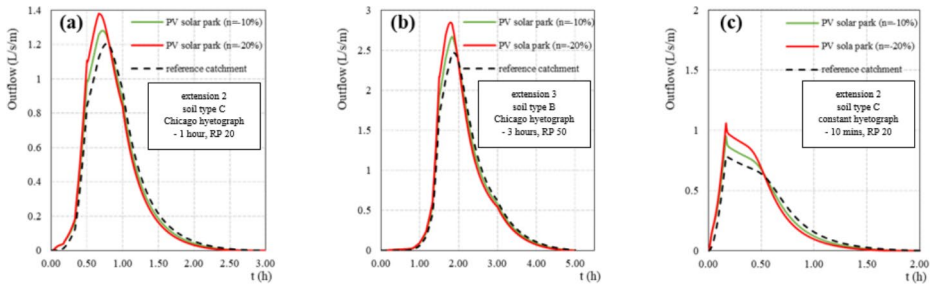
Temporal distribution of the rainfall does not influence the aggravation of outflow from the solar park as compared to the reference catchment. Indeed, Figs. 3b and 7b report results of simulations carried out for parks of same extension and soil type, in which the 1-hour, 20-years RP precipitation event is given as input in the form of a Chicago hyetograph (Fig. 3b) or constant rainfall (Fig. 5b). In both cases, outflow curves from the solar park follow the corresponding curves from the reference catchment during the whole simulation.



**Fig. 4** Outflows from the PV solar park and from the reference catchment for different soil types (short-term condition)



**Fig. 5** Outflows from the PV solar park and from the reference catchment for different duration of the precipitation event (short-term condition)



**Fig. 6** Outflows from the PV solar park and from the reference catchment for different combinations of model parameters and precipitation inputs (long-term analysis)

Finally, simulations that differ only for the RP of the precipitation event also led to outflow curves from the solar park practically equal to those from the reference catchment, regardless of the magnitude of the event.

Globally, no significant increments of the peak flow and of the total runoff volume from the solar park as compared to the reference catchment were observed in all the 135 simulations for short-term condition. This result is in line with modelling and experimental findings of previous studies (Cook and McCuen 2013; Wang and Gao 2023).

To evaluate the effects of possible long-term changes in land cover induced by the presence of the PV installation, a reduction of the roughness surface is supposed for subcatchments representing corridors and under-panel areas in the model. In particular, the original Manning coefficient for those subcatchments is progressively reduced by 10% and 20% (i.e.,  $n=0.135$  and  $n=0.12$ , respectively). Figure 6 shows comparison between outflows from the PV solar park and from the reference catchment for 3 long-term condition simulations. Model parameters and precipitation inputs of the simulations related to Fig. 6a, b and c are the same of those discussed for Figs. 3b, 4b and 5a, respectively.

In all the simulations, the reduction of the surface roughness surface in corridors and under-panel areas leads to increased peaks flow as compared to the short-term analysis. For the events analysed in Fig. 6, a 10% reduction of the Manning coefficient results in peak flow increases of about 6% (Fig. 6a), 8% (Fig. 6b) and 21% (Fig. 6c). The percentage of peak flow increase is even greater if the Manning coefficient is reduced by 20% (15% increase for events in Figs. 6a and b and 35% for event in Fig. 6c).

The reduced roughness surface allows for a faster surface runoff from the upstream part of the solar park towards the outlet. Indeed, both the rising and the recession limb of the hydrograph from the solar park are anticipated with respect to those of the hydrograph from the reference catchment. Runoff velocity increases passing from a 10% to a 20% reduction of the Manning coefficient for all the events showed in Fig. 6. Also this result is in agreement with simulation studies carried out by Cook and McCuen (2013).

As a consequence of the increased runoff velocity, total runoff volumes from the solar park are greater than those from the reference catchment for all analysed events. Indeed, the potential of water infiltration is related to the ponding time above the subcatchment surface, which decreases as runoff velocity increases. For the events showed in Fig. 6, runoff volumes from the solar park increase with respect to the reference catchment in the order of 1–3% for a 10% Manning coefficient reduction and in the order of 2–5% if the Manning coefficient is reduced by 20%.

## 5 Conclusion

In this paper a modelling framework for the simulation of stormwater runoff in ground-mounted photovoltaic solar parks is proposed. EPA-SWMM software is used in a novel way to model all the elements in the solar park and their mutual interactions during precipitation events.

The modelling exercise showed the potentialities of the proposed conceptualization. Specifically, by comparing outflow discharges from the park and from a reference catchment (pre-installation condition), the proposed approach was successful in simulating some of the main impacts of PV power plant realization on peak flow and total runoff volume. In particular, simulations were run considering 3 different sizes of the PV installation (small, medium, large), 3 different soil types and input hyetographs of different return periods, shapes and durations. A first set of simulations have been run by assuming the same roughness surface for the solar park and the reference catchment (short-term condition). Then, the impacts of the presence of the panels rows (as well as of the maintenance activities) on the roughness surface have been considered. The proposed conceptualization allows to successfully simulate the spatial redistribution of the rainfall and infiltration fluxes due to the presence of the panel rows. The modelling exercise shows that when the surface roughness of the solar park is decreased, peak flow increases in the order of 6–35% as compared to the pre-installation scenario. Increased values (1–5%) of the total runoff volume are obtained as well.

The proposed modelling framework may be useful for operators in the field of photovoltaic for the evaluations of the outflow discharge from the solar park for different configurations of the installation, soil type and ground cover. The use of a free and open-source software adds value to the research and could represent a boost for the development and the improvement of the modelling framework as well as for a simple and wide diffusion of the results. Future availability of experimental data on runoff from solar park would help increasing the reliability of the obtained results; further investigations will also attempt to extend model applications at the watershed scale.

Future steps of the work may include the evaluation of other impacts on the ground cover induced by presence of the PV installation as well as the investigation of the solar park

behaviour in long period simulations. Finally, other layouts of the PV installation should be considered in future works, especially those implying a reduction of the available area for infiltration within the park.

**Author Contribution** Aurora Gullotta: Conceptualization, Methodology, Software and Writing – Original draft. Tagele Mossie Aschale: Conceptualization, Methodology, Software. David J. Peres: Supervision, Funding acquisition, Writing – Review & Editing. Guido Sciuto: Supervision. Antonino Cancelliere: Supervision, Funding acquisition, Project administration.

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**Data Availability** The data presented in this study are available on request from the corresponding author.

## Declarations

**Ethical Approval** Not applicable.

**Consent to Participate** Not applicable.

**Consent to Publish** Not applicable.

**Competing Interests** The authors have no relevant financial or non-financial interests to disclose.

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