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Corresponding Author	Family Name	**Grasso**
	Particle	
	Given Name	**Marco**
	Suffix	
	Division	
	Organization	Università degli Studi di Milano-Bicocca
	Address	Milan, Italy
	Email	marco.grasso@unimib.it
Author	Family Name	**Moneo**
	Particle	
	Given Name	**Marta**
	Suffix	
	Division	
	Organization	Università degli Studi di Milano-Bicocca
	Address	Milan, Italy
	Email	
Author	Family Name	**Arena**
	Particle	
	Given Name	**Marco**
	Suffix	
	Division	
	Organization	Università degli Studi di Milano-Bicocca
	Address	Milan, Italy
	Email	

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Abstract

Climate change severely impacts on the natural and socio-economic systems of the Pacific Islands. Samoa, a small insular state of the region, is characterized by widespread awareness of climate change reflected by its leading international role. This also makes Samoa a potentially exemplary reference for the Pacific Islands. Against this backdrop, the overall aim of this article is to investigate the notion of social vulnerability and measure its dimensions in Samoa through a specific index: the Samoa Social Vulnerability Index (SSVI). The SSVI may yield better understanding of the characteristics and dynamics of social vulnerability, as well as information for fostering adaptation strategies in Samoa and in the Pacific Islands. In particular, the article first outlines the major vulnerabilities to climate change in Samoa and then analyses the composite notion of social vulnerability. On this basis, the article methodologically specifies, designs and constructs the SSVI. Afterwards, it uses such index for measuring the dimensions of social vulnerability in Samoa's districts.

	Finally, some considerations are made concerning the policy relevance of the SSVI and its potential regional role.
Keywords (separated by '-')	Adaptation - Climate change - South Pacific - Social vulnerability - Social Vulnerability Index
Footnote Information	The opinions expressed in this article are those of the authors and do not necessarily reflect the views or policies of UNDP Samoa.

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ORIGINAL ARTICLE

Assessing social vulnerability to climate change in Samoa

Marco Grasso · Marta Moneo · Marco Arena

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Abstract Climate change severely impacts on the natural and socio-economic systems of the Pacific Islands. Samoa, a small insular state of the region, is characterized by widespread awareness of climate change reflected by its leading international role. This also makes Samoa a potentially exemplary reference for the Pacific Islands. Against this backdrop, the overall aim of this article is to investigate the notion of social vulnerability and measure its dimensions in Samoa through a specific index: the Samoa Social Vulnerability Index (SSVI). The SSVI may yield better understanding of the characteristics and dynamics of social vulnerability, as well as information for fostering adaptation strategies in Samoa and in the Pacific Islands. In particular, the article first outlines the major vulnerabilities to climate change in Samoa and then analyses the composite notion of social vulnerability. On this basis, the article methodologically specifies, designs and constructs the SSVI. Afterwards, it uses such index for measuring the dimensions of social vulnerability in Samoa's districts. Finally, some considerations are made concerning the policy relevance of the SSVI and its potential regional role.

Keywords Adaptation · Climate change · South Pacific · Social vulnerability · Social Vulnerability Index

Introduction

The adverse impacts of global climate change are unevenly distributed across regions and countries, for they ultimately depend on the vulnerability and adaptability of different natural and social systems. The South Pacific is one of the most socially, culturally and environmentally complex and diverse regions of the planet. Specially, in small insular states, 'adaptive capacity of human systems is generally low… and vulnerability high', so that Pacific Islands 'are likely to be among the countries most seriously impacted by climate change' (IPCC 2001: 17, table SPM 2). Pacific Islands may in fact be subject to a variety of potential climate threats: sea-level rise, human health issues, problems with the water balance, biodiversity loss, disruption of the tourism industry, reduction in fisheries and in subsistence and commercial agriculture and endangerment of food security (IPCC 2007; Barnett 2011). This holds in particular for Samoa (Samoa Meteorological Division 2007), a small South Pacific island developing state (SIDS) whose socio-economic dynamics are severely exposed and sensitive to climate change (Samoa Ministry of Natural Resources, Environment and Meteorology (MNRE) 2005; Government of Samoa 2009b). The country is also characterized by widespread awareness of climate change among both institutions and civil society, as reflected by its leading role in political debate and negotiations in the region and internationally (ODI et al. 2012). This ultimately makes the Samoan context a potentially exemplary reference for the Pacific Islands.

Against this backdrop, the overall aim of the article is to investigate the multifaceted notion of social vulnerability and measure its dimensions across Samoa's districts through an index specifically designed and constructed: the Samoa Social Vulnerability Index (SSVI). This index,

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M. Grasso (✉) · M. Moneo · M. Arena
Università degli Studi di Milano-Bicocca, Milan, Italy
e-mail: marco.grasso@unimib.it

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given the greater grasp of the dynamics and characteristics of social vulnerability that it provides, may both yield information at different governance levels for supporting adaptation strategies and be used to assess their outcomes in the country and across the entire region. Specifically, the article first outlines the major vulnerabilities of Samoa to climate change; then, it analyses the composite notion of social vulnerability. On this basis, the article specifies the methodological issues raised by the SSVI, and designs and constructs the index. The SSVI is subsequently employed for measuring the dimensions of social vulnerability across Samoa's districts. Finally, the article discusses the policy relevance of the measurement of the dimensions of social vulnerability carried out through the SSVI and the potential for the extension of the index across the Pacific Islands.

The vulnerabilities of Samoa to climate change

In order to contextualize and explain the following theoretical investigation of social vulnerability, the related rationale and structure of the SSVI and its use for measuring the dimensions of social vulnerability in Samoa, it is first necessary to outline the main vulnerabilities of the country, i.e. the exposure and sensitivity of its natural and socio-economic systems to climate change.

Samoa comprises two large volcanic islands (Upolu and Savai'i) and several smaller ones with a total area of 2,831 km^2 and a population of 187,820 (Samoa Bureau of Statistics 2011). As an SIDS of the South Pacific region Samoa is particularly vulnerable to extreme weather events and, given its relative small area and its latitudinal extension, it is almost homogeneously affected by climate change (Government of Samoa 2013) (Fig. 1).

According to the National Adaptation Plan of Action (NAPA) (Samoa MNRE 2005), climate change and variability significantly and evenly distress Samoa's natural and socio-economic systems, whose intertwined vulnerabilities are mutually magnified and reinforced. As regards natural systems, water has always been a major issue, extremely sensitive to climatic patterns: its poor quality, scant availability and difficult accessibility impact directly on the livelihoods of Samoan people. For instance, in 2006, Samoa experienced a severe water shortage due to a 57 % below average rainfall (Government of Samoa 2011). This problematic situation is worsened by sea-level rise, projected to be 0.19–0.58 m by 2100 (Mimura et al. 2007), since this increases the possibilities of seawater intrusion into underground water aquifers as already experienced by many coastal communities. Moreover, in the past decade, increasingly severe and more frequent droughts have caused four major fires that have jeopardized forests and

Fig. 1 The South Pacific region and Samoa

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their role in watershed management, environmental protection, provision of wood and non-timber resources, and as reserves of biodiversity. Samoa's biodiversity is, in fact, being severely harmed by climate change: besides the threats posed by extreme weather and climatic events, biodiversity is also prone to temperature fluctuation—1–3 °C by 2070, with associated increases in sea surface temperature of Mimura et al. 2007, and changes in precipitation patterns— from −14 to +15 % by 2070 (Mimura et al. 2007). These factors have already led to changes in the habitats of endangered and endemic species, especially forest birds, whose populations have been decimated. Likewise, the intense wave activity of storms has destroyed much of the inshore coral reef and severely damaged deep-water corals.

Turning to socio-economic systems, climate impacts affect income-generating activities for communities and the country at large. Coastal infrastructure assets, given the cost incurred for their construction and maintenance, are a highly sensitive issue for the Samoan economy. Without proper projects and implementation of coastal infrastructure management (CIM) plans, such infrastructures are highly vulnerable to climate impacts. Another important socio-economic sector severely affected by climate change is tourism. Major impacts include loss of beaches, flooding and degradation of coastal ecosystems, saline intrusion and damage to key tourism infrastructures that hamper the industry as a whole. The loss by coral of its attractiveness due to the bleaching and heat stress triggered by high humidity—a major cause of tourism disruption—is generally regarded by the relevant Samoan institutions as due to climate change. It should also be noted that human health has been endangered by climate change: there is evidence of an increase in vector-borne and water-borne diseases mostly brought about by the altered climatic conditions.

Samoa is also subject to extreme weather and climate events, such as heavy rainfall, strong winds, cyclones and droughts (Government of Samoa 2011). These and other natural disasters are already occurring, especially in the most sensitive natural and socio-economic systems mentioned above. They have claimed lives and caused severe damage to infrastructures and other economic assets. One example is the recent cyclone Evan that hit Samoa in December 2012 and caused immense damage and significant losses. The value of durable physical assets across all economic and social sectors destroyed by Evan (referred to as 'damage') is estimated at US$ 103.3 million, a significant amount for the small and fragile Samoan economy (Government of Samoa 2013). Similarly, cyclones Ofa in 1990 and Val in 1991 caused damage to agriculture, infrastructure and other assets in the order of 2.5–3 times Samoa's GDP in 1990 (Government of Samoa 2013). Extreme events are projected to escalate in the short and longer period in both frequency and intensity (Mimura et al. 2007). Hence, they very will likely have significant impacts on livelihoods in Samoa in the foreseeable future.

Indeed, the possibility to deal with such vulnerabilities largely depends also on the capacity to provide proper institutional responses. As a consequence, the next section examines the notion of social vulnerability, given that such theoretical investigation makes it possible to properly focalize the subsequent measurement of its dimensions in Samoa through the SSVI.

Social vulnerability

The capacity of natural and socio-economic systems to counter climate change mainly centres, as underlined, on the vulnerabilities—those of Samoa are sketched in the previous section—of the systems under scrutiny, as well as on the capacity to develop adaptation responses. Therefore, before designing and constructing the SSVI and using it for measuring the dimensions of social vulnerability in the Samoan context, it is necessary to explore the complex notion (Turner et al. 2003) of vulnerability and its relationship with adaptive capacity.

It is generally agreed that there are two different interpretations of vulnerability in relation to global climate change: on the one hand, vulnerability is the net impact of climate change and is therefore seen as an 'end point'; on the other, vulnerability is seen as a 'starting point', a state of a system produced by socio-economic processes and triggered by climate impacts (Kelly and Adger 2000; O'Brien et al. 2004).

The end-point interpretation assumes that adaptation initiatives determine vulnerability, so that present adaptive capacity refers to future adaptation and vulnerability. In this *biophysical* perspective, adopted in the previous section for describing Samoa's vulnerabilities, climate impacts are the main determinants, and the reductions in carbon emissions and in the sensitivity of social, environmental and economic systems to climate impacts are the primary solutions. However, although this view provides the factual evidence necessary to contextualize the multifaceted notion of vulnerability and consistently shapes the architecture of a relative index, it does not seem sufficient in itself for the purposes of this article. Such a perspective, in fact, by and large excludes socio-economic aspects that are of the utmost importance in relation to South Pacific SIDS (Grasso 2006). Consequently, adopted here is the starting-point notion of vulnerability in order to underline the centrality of socio-economic dimensions (Adger 1999; Kelly and Adger 2000; Brooks et al. 2005). In other words, the focus is on prior conditions and not on future stresses, as excellently synthesized by the image of the 'wounded

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soldier' (Kelly and Adger 2000: 328). According to this apt metaphor, the vulnerability of individuals or communities to climate hazards is principally determined by their 'capacity to respond to that hazard, rather than by what may or may not happen in the future' (Kelly and Adger 2000: 328). Hence, the causal relation operates in reverse, because it is ultimately vulnerability that determines adaptive capacity and adaptation. Put slightly differently, starting-point vulnerability is 'the ability or inability of individuals and social groupings to respond to, in the sense of cope with, recover from or adapt to any external stress placed on their livelihoods and well-being' (Kelly and Adger 2000: 328), and its causes are related to social, institutional, and economic factors, as well as to climate impacts. It should be noted that starting-point vulnerability is not separate from exposure and sensitivity, in that it is necessarily linked to specific climate impacts (Kelly and Adger 2000). However, in our case, as made clear below, given Samoa's high homogeneity in terms of exposure and sensitivity to climate hazard, when calculating the dimensions of social vulnerability through the SSVI, we will not consider such external variables and focus only on internal ones, i.e. on socio-economic aspects.

In sum, the starting-point perspective on vulnerability to climate change is better able to grasp the processes of social adaptation to climate impacts and to lay the bases for an index with which to measure social vulnerability. The application of such index makes it eventually possible to shape adaptation policies and ponder their outcomes, because the focus is on the socio-economic, institutional and political context determining the ability to cope with climate impacts.

Given this focus, starting-point vulnerability is also strictly linked to, and intertwined with, the capacity to put forward adaptation responses. Adaptive capacity is quite unambiguously defined as 'the potential of a system, region or community to adapt to the effects or impacts of climate change' (Smit and Pilifosova 2001: 881). There are many possible socio-economic characteristics of systems that mutually determine their capacity to adapt. In particular, adaptive capacity is expected to increase when the country is rich and stable; there exist proper institutional structures; there is widespread access to technology; the responsibility for adaptation is clear; climate information is accessible; and resources are equitably allocated (Smith and Pilifosova 2001: 888–889). According to O'Brien et al. (2004), adaptive capacity has two interpretations that are closely intertwined with the end-point and starting-point understandings of vulnerability. On the end-point interpretation, adaptive capacity is a measure of the success of technological climate change adaptation and relates to future adaptation and vulnerability; whereas on the starting-point interpretation, it is the actual ability to deal with climate stress and thus relates to present-day vulnerability. This latter interpretation, which is favoured by this article, envisions adaptive capacity as the set of socio-economic resources available for adaptation, as well as the capacity to use these resources for effective adaptation strategies. In short, adaptive capacity represents potential adaptation. On this understanding, the major components of adaptive capacity have been identified by Brooks et al. (2005) and Adger and Vincent (2005) as information about the nature and evolution of climate impacts and about socio-economic systems; financial, social, human and natural resources; acknowledgement of the risk associated with climate change and of the ensuing responsibilities for adaptation; good governance processes and political rights; health; literacy; economic well-being.

In light of these considerations, it is therefore possible to argue that adaptive capacity is part of the notion of social vulnerability whose definition and measurement in Samoa through the SSVI is the primary objective of this article.

The Samoa Social Vulnerability Index: methodological issues

In this section, we specify the most relevant methodological aspects that characterize the construction of an index—the SSVI—with which to assess the dimensions of social vulnerability in Samoa, as well as in the Pacific Islands.

Before doing so, it should be stressed that the SSVI is not meant to be a measure of performance or a policy tool *tout court*: rather, it is a means to gain better understanding of the dynamics and characteristics of social vulnerability and to highlight the consequent entry points for the design of more effective adaptation strategies. On this latter understanding, the rationale for its use is twofold. On the one hand, the information provided by the SSVI can support adaptation strategies locally, nationally and regionally, for it identifies issues that should be addressed by governance systems at different levels in order to tackle climate impacts (UNEP and SOPAC 2005). On the other hand, the SSVI is an efficient means for a more complete assessment of adaptation strategies.

Methodological specifications

Two major methodological specifications about the construction of the SSVI are in order.

First, a comprehensive index of vulnerability must consider both the socio-economic variables that characterize the system and the rate and magnitude of climate change affecting the system. However, consistently with the notion of social vulnerability adopted, the SSVI takes account only

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of socio-economic variables. It does so on the basis of a specific methodological choice prompted by factual evidence. Samoa, in fact, is characterized by high heterogeneity in terms of socio-economic variables, but it is markedly homogeneous in terms of *biophysical* vulnerability, as made clear above. In other words, the different areas of Samoa have roughly the same exposure and sensitivity to physical stresses—as was confirmed by the stakeholder consultations (see below). According to the Samoan MNRE's experts, this is due to the country's relatively small size and its latitudinal geographical extension, which entail negligible differences in terms of climate patterns impossible to capture by downscaling climate models.

The second methodological issue, one common to all multidimensional indices, concerns the measurement process. The aggregation of variables with different units made it necessary to carry out standardization. Consistently with most of the literature (Barnett et al. 2008), it was decided that the parameters of this standardization should be the highest and lowest values of each variable. Given this choice, we expected a high variability in the standardized indicators values (ranging from 0 to 1) even if the variability among the non-standardized values was not large. This aspect, together with the assumption that all SSVI variables (i.e. determinants and indicators, see Table 1) were linearly correlated with social vulnerability, are some of the evident methodological weaknesses of the SSVI.

Nevertheless, this straightforward approach avoided controversial and weak assumptions and allowed for consistency across all determinants and indicators.

Participatory design process: stakeholder consultations and feedback

A crucial methodological feature of the SSVI is the participatory process of selection and contextualization of its indicators. In fact, a distinctive characteristic of our work, consistently with the need for objectivity in indicators (Anand and Sen 1997), is its inclusion of local stakeholders and experts in the SSVI design process. This approach was primarily adopted to shape and validate our construct and to avoid arbitrary assumptions, but also to deliver a participation-based climate policy tool for Samoa.

Given these goals, the process was divided in two distinct phases: one-to-one consultations and a final stakeholder's workshop.

The one-to-one consultations were conducted at an early stage in order to define, together with the relevant stakeholders, possible variables with which to measure the dimensions of social vulnerability of their particular sectors. Six different meetings were organized with representatives from the Meteorological Department of the Samoa MNRE, the Samoa Ministry of Health (MOH) and the SBS. These meetings were important both to understand data availability and limitations, and to gather directly from local decision-makers preliminary views on the articulation of the index and its possible application to adaptation policy. For instance, one of the most significant issues that emerged from one-to-one consultation with the Meteorological Department of the MNRE was that, historically, Samoa's physical exposure to extreme phenomena, such as cyclones or droughts, has been substantially homogeneous throughout the country, as already pointed out. Such evidence reinforced our decision to focus on the social determinants of vulnerability. This insight is an example of the synergies and opportunities that arose from working directly with local policy-makers and practitioners. We in fact believe that their knowledge was essential not only to highlight limitations of our methodology but also to prevent the SSVI from being a mere academic exercise.

We presented a draft of the SSVI at the final stakeholder workshop. The main aim of this meeting was to gather feedback on the structure of the index, collectively weight the different determinants and indicators, and then to discuss the SSVI applications. The participants in the final workshop were 25 ministry officials (representatives from different departments of the MNRE, MOH, SBS, of the Ministry of Agriculture and Fishery and of the Ministry of Finance), donors (a delegate from the Australian Ministry of Environment and Climate Change) and international agency technical officers (UNDP, UNEP, FAO, SPREP (Secretariat of the Pacific Regional Environmental Programme)), and they expressed genuine interest in the potential of the SSVI. The numerous inputs received mostly concerned the inclusion of new indicators in the SSVI and their better specification. Some of these suggestions were incorporated into the final SSVI: for instance, water and population density indicators were included, as well as the MOH's suggestion of including the distance of communities from clinics and hospitals in the indicator of health-related vulnerability. Other inputs concerned the disaggregation of the SSVI into several sector-based sub-indices, since, according to this perspective, a cross-cutting measure of social vulnerability would not have operational application in terms of adaptation programmes. This ultimately strengthened the informative role given to the SSVI determinants in the assessment of social vulnerability in Samoa carried out.

The second issue discussed at the final stakeholder workshop concerned the delicate question of the weights of determinants and indicators. The initial idea was to let participants weight them and then to make an average of their choices and finally to obtain the weights based on the overall experts' judgement. However, after showing a sensitivity analysis which highlighted that the distribution of social

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Table 1 Measuring the dimensions of social vulnerability: the Samoa Social Vulnerability Index (SSVI)

SSVI determinant	Context	Indicator	Relationship between indicator and social vulnerability	Data source
Economic Welfare	Income	Household weekly expenditure	Inverse relationship	Samoa Bureau of Statistics (2008a)
	Inequality	Gini coefficient	Direct relationship	Samoa Bureau of Statistics (2008a)
	Dependence	Percentage of remittances in total income	Inverse relationship	Samoa Bureau of Statistics (2008a)
	Incidence of Poverty	Percentage of people below the basic needs poverty line	Direct relationship	Samoa Bureau of Statistics (2008b)
Social Wellbeing	Dependency ratio	Population aged under 15 and over 64 as percentage of total of working-age (15–64) population	Direct relationship	Samoa Bureau of Statistics (2011)
	Education	Percentage of people in secondary and tertiary education	Inverse relationship	Samoa Bureau of Statistics (2011)
	Health	Distance from the hospital weighted per number of beds available	The greater the distance, the higher the social vulnerability The higher the number of beds, the lower the social vulnerability	Authors' elaboration based on NHS figures and MNRE maps
	Gender empowerment	Percentage of female workers in the total (total number by sex)	The closer to 50 % is the percentage, the lower the social vulnerability	Samoa Bureau of Statistics (2011)
Infrastructure and Technology	Communication	Percentage of households owning a mobile telephone and Percentage of households with an internet connection	Inverse relationship	Samoa Bureau of Statistics (2011)
	Agricultural equipment	Percentage of farmers owning at least one of the following agricultural equipment: tractor, roto-tiller and water irrigation pump	Inverse relationship	Samoa Bureau of Statistics (2009)
	Water	Percentage of people without access to piped water	Direct relationship	Samoa Bureau of Statistics (2011)
	Population Density	Population per km^2	Direct relationship	Samoa Bureau of Statistics (2011)
Structure of the Economy	Agriculture	Percentage of households engaged in agriculture (including agriculture for subsistence, home consumption and sale)	Direct relationship	Samoa Bureau of Statistics (2009)
	Fishery	Percentage of households engaged in fishing (fishing is considered for home consumption, home consumption with occasional selling, and mainly for sale)	Direct relationship	Samoa Bureau of Statistics (2009)
	Tourism	Percentage of households engaged in tourism	Direct relationship	Samoa Bureau of Statistics (2011)

Source Authors' choices and considerations taking account of relevant stakeholders' inputs

vulnerability did not radically change, we agreed that such weights should be equal. The sensitivity analysis carried out consisted in the presentation at the stakeholder workshop of five scenarios with different weights attached to the determinants of social vulnerability. Such analysis showed, as said, that the overall SSVI values across the Samoan communities did not change significantly from case to case. Therefore, in agreement with the participants, we eventually decided not to choose any particular scenarios and to keep the weights of each determinant equal. In our opinion, although this equal-weight approach could be criticized because it considers every dimension as equally important in determining social vulnerability, it is robust and transparent and avoids arguable value judgements.

Construction of the Samoa Social Vulnerability Index

A vast literature on climate change vulnerability indices has been produced in the last two decades to address the

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growing demand among stakeholders for spatially explicit information regarding sensitivity, adaptive capacity and vulnerability to climate change on any scale (Preston et al. 2011) The approaches adopted are extremely heterogeneous, and they vary in terms of objects of the index, scope, area analysed and sector considered (for a methodological overview see, for instance, Adger et al. 2004). Numerous indices have a global reach (e.g. UNEP and SOPAC 2005) while others focus on a particular region (e.g. Vincent 2004) or on a national/local area (e.g. O'Brien et al. 2004). Or, again, some indices may focus on the system as a whole, or on a particular sector such as water (e.g. Preston and Jones 2008) or agriculture (e.g. Grasso and Feola 2012). As for Samoa, Hay (2006) put forward a quantitative analysis of climate-related risk that included extreme rainfall events, drought, high sea levels, extreme winds and extreme high air and water temperatures. Likewise, the Secretariat of the Pacific Community has developed an index, the Climate Risk Profile (CRP), to investigate Samoa's vulnerabilities to climate change (SOPAC 2011), which, in fact, yields results different from those of the SSVI. The differences are mainly due, in our opinion, to the dissimilar objects and purposes of the two indices. In fact, the CRP identifies and estimates the areas where the absolute value of material losses due to climate change is higher, and it can prove a tool useful for infrastructure planning.

The SSVI, instead, assesses the dimensions of social vulnerability of communities by focusing on the capacity of households to cope with climate impacts, and it is ultimately useful for the definition of development strategies targeting support to livelihoods through adaptation. To this end, the SSVI is characterized by a composite construction and measures social vulnerability for each of the 41 districts corresponding to the electoral constituencies of Samoa—which in practical terms can be understood as communities.

Specifically, the SSVI's structure, which partly derives from the Social Vulnerability Index developed for the African region (Vincent 2004), is articulated into four different determinants—(1) economic welfare; (2) social well-being; (3) infrastructure and technology; and (4) structure of the economy—which refer to diverse contexts, and each of which is composed of a set of three to four different indicators. To be noted is that, the first three determinants of the SSVI mostly focus on the ability of communities to cope with climate change, whereas the last one centres on the ability of crucial sectors of the Samoan economy to do so.

The determinants and the related indicators of the SSVI cover, in our view, the main constituents of starting-point vulnerability highlighted above, and they were consistent with stakeholders' expectations. As explained, the SSVI design process was, in fact, conducted in consultation with the main stakeholders involved in the Samoan adaptation processes.

We ultimately believe that the SSVI is consistent with the three lessons for the construction of indices of vulnerability put forward by Barnett et al. (2008). It is in fact (1) calculated at sub-national level (i.e. the district, which in Samoa can be considered a community); (2) it is intended as a means to gain better understanding of social vulnerability—and not as a measure of performance—that can eventually have policy relevance; and (3) it takes account of inputs from experts and stakeholders.

The dimensions of social vulnerability in Samoa

In this section, we analyse in detail the dimensions of social vulnerability included in the SSVI in order both to highlight their actual measures across Samoa's districts and to better frame and interpret such measures as well as the potential of the SSVI.

We present below a synoptic table of the dimensions, i.e. the determinants and indicators, of social vulnerability that the SSVI assesses. Table 1 also highlights, in the fourth column, the functional relationships between indicators and social vulnerability that we envisaged in accordance with the relevant stakeholders. In particular, a direct relationship implies that the higher (lower) the indicator, the higher (lower) is social vulnerability, whereas an inverse relationship entails that the higher (lower) the indicator, the lower (higher) the social vulnerability.

It should be first pointed out that a crucial general factor augmenting Samoa's social vulnerability is its limited access to socio-economic resources, including traditional ones, a circumstance that greatly reduces adaptive capacity to climate change. Samoa has, in fact, an insufficient base of local sustainable economic opportunities, and it is losing its traditional sustainable life skills as its natural resources and culture respond to both internal and external pressures. Furthermore, similar to other Pacific Island economies, Samoa is also highly sensitive to external economic fluctuations and changing world trade policies and practices.

Economic welfare

The first SSVI determinant concerns the population's welfare. Income is indeed central to social vulnerability, and it is understood in terms of household weekly expenditure. There is, in fact, general consensus that expenditure, a variable strictly related to income, plays a key role in reducing vulnerability by preventing risks and in increasing

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adaptive capacity by providing resources to respond to external shocks (Kelly and Adger 2000). The average household expenditure in Samoa is US$ 840 per week, with the highest value of US$ 989 in the Apia Urban Area and the lowest of US$ 708 in the Rest of Upolu region (Samoa Bureau of Statistics 2008a). But, expenditure by itself cannot, for instance, capture situations of high resource concentration that constrains household adaptive capacity based on private assets (Adger 1999). Therefore, we included an indicator describing the distribution of income among the population, the Gini coefficient, which ranges from 0.44 in the rest of Upolu region to 0.48 in the Apia Urban Area and has an average value of 0.47 (Samoa Bureau of Statistics 2008a). We also used an indicator that depicted the proportion of income from remittances: it varies between 5.7 % in the Apia Urban Area to 18.0 % in the Savai'i region, with an average value for the country of 10.8 % (Samoa Bureau of Statistics 2008a). In particular, remittances are related to the capacity to rely on external resources in emergencies. The SBS, in fact, observed in its post-disaster risk assessment of the tsunami that hit Samoa in 2009 (Government of Samoa 2009a) that remittances were the main source of support for livelihoods after the disaster. The population below the basic needs poverty line was also part of this determinant, since this indicator highlighted the percentage of people lacking the basic resources to adapt. Such indicator has an average value for Samoa of 19.8 % and shows a distribution similar to that of the previous one, with the lowest value of 17.2 % in the Apia Urban Area and the largest one of 21.9 % in the Savai'i region (Samoa Bureau of Statistics 2008b).

Social well-being

Social well-being comprises the demographic, cultural and health characteristics that influence social vulnerability. The demographic structure of the population plays a crucial role because, by and large, older and younger age groups are those most sensitive to environmental risks (O'Brien and Mileti 1992). This is due to their fewer material means and lower psycho-physical capacity: hence, a disproportionate number of people belonging to these age groups would be a burden on the active population, compromising its flexibility and overall capacity to adapt. In order to measure this aspect, we used an indicator of dependency, intended as population aged under 15 and over 64 as percentage of the working-age (15-64) population, which spans from 68.1 % in the Apia Urban Area to 84.3 % in the Savai'i region, with an average value for the country of 76.1 % (Samoa Bureau of Statistics 2011). We included education since it enhances the access to, and understanding of, climate-relevant information: there is much evidence that education markedly improves the capacity for future planning and the willingness to change risky behaviour (Neisser et al. 1996). The indicator of education, the percentage of people in secondary and tertiary education, has an average value of 48.8 % and is highest (56.7) in the Apia Urban Area (Samoa Bureau of Statistics 2011). Consistently, with Brooks et al. (2005), it was understood that health variables are significantly correlated to social vulnerability. Hence, as emphasized, in consultation with the Ministry of Health, we created an indicator measuring the accessibility of health care as a proxy for the population's state of health. Accessibility was measured by the distance from Samoa's two main hospitals weighted for the number of beds available and is great variable throughout the 41 Samoa's districts. Finally, considering that climate change is expected to exacerbate inequality and to have a more severe impact on weaker strata of the population (Grasso 2010), we also included an indicator of gender inequality, measured as the percentage of female workers in the total working population: it spans from 38.2 % in the Apia Urban Area to 17.7 in the Savai'i region, with an average value of 27.5 % (Samoa Bureau of Statistics 2011).

Infrastructure and technology

Infrastructure and technology, especially in the case of the extreme events so frequent in the region considered, are of crucial importance for coping with adverse climate impacts (Smit and Wandel 2006). To capture this aspect of social vulnerability, we used four indicators, respectively, focused on communication, agriculture, water and population density.

Given that better communications imply easier access to climate information and forecasts, the percentage of households with a mobile phone and/or an Internet connection was adopted as a measure of preparedness for hazardous extreme climatic events. Such indicator ranges from 42.9 % in the rest of Upolu region to 45.9 % in the Savai'i region, with a country average of 43.9 % (Samoa Bureau of Statistics 2011). Also the level of mechanization of agriculture is of relevance to the adaptive capacity of this sector. The proxy used to measure the level of mechanization was the percentage of farmers owning at least one of the agricultural implements indicated in Table 1, and it is evenly distributed in the Samoan regions (Samoa Bureau of Statistics 2009). Furthermore, as pointed out above, it emerged at the stakeholder workshop that it was necessary to take account of other fundamental variables. We therefore included two of the indicators proposed by the stakeholders: access to water, and population density. As for the water sector, which also the NAPA (Samoa MNRE

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2005) identifies as highly sensitive to climate impacts, as underlined above, we created a proxy-capturing reliable access to good-quality water and measured as the percentage of people without access to piped water. Such indicator shows similar scales across the Samoan districts and has an average value of 1.8 % (Samoa Bureau of Statistics 2011). Finally, considering that 70 % of Samoa's population and infrastructure are located in low-lying areas susceptible to sea-level rise (Samoa MNRE 2005) and that population density is a major obstacle to relocation strategies, we included an indicator of population density that had a direct functional relationship with social vulnerability. It ranges from 612 people per km^2 in the Apia Urban Area to 26 in the Savai'i region, with an average value of 67 (Samoa Bureau of Statistics 2011).

Structure of the economy

This final determinant of the SSVI investigated the exposure of the Samoan districts' economies to climate change. Although all sectors are strictly interconnected and they are therefore all inherently susceptible to external shocks, it seems possible to identify sectors that are both more directly exposed to climate change and relatively more significant for the Samoan economy. New weather patterns, extreme climate events, sea level rise, ocean acidification and change in the temperature of sea water are, in fact, directly affecting Samoa's agriculture, fishery and tourism (Samoa MNRE 2005). To capture the impacts of climate change on these sectors, we considered the percentage of households involved in agriculture—lowest 36.0 % in the Apia Urban Area, highest 96.1 % in the Savai'i region, average 84.1 % (Samoa Bureau of Statistics 2009), fishery—lowest 5.3 % in the Apia Urban Area, highest 41.8 % in the North-West Upolu region, average 24.8 % (Samoa Bureau of Statistics 2009)—and tourism—lowest 0.6 % in the Savai'i region, highest 1.3 % in the Apia Urban Area, average 0.9 % (Samoa Bureau of Statistics 2011)—as a measure of social vulnerability. A higher value corresponded to greater social vulnerability because districts more reliant on climate change-sensitive activities are more likely directly to experience losses of income and tax revenues.

Results

After calculating the overall value of each SSVI determinant as the arithmetic mean of the relevant standardized indicators, the determinants, as anticipated, contributed equally to the calculation of the SSVI, as often happens with composite indices of vulnerability (Barnett et al. 2008). In other words, although we could have attributed different weights to the different determinants and/or indicators, we saw no obvious reason for doing so. Consequently, we chose equal weights for both determinants and indicators. It is worth specifying that this, like all final choices about the SSVI, was decided by the authors, with the consequent inevitable degree of subjectivity (Vincent 2004).

The SSVI ranges from 0 to 1, where 0 corresponds to no relative social vulnerability and 1 to maximum relative social vulnerability. The map below shows the SSVI values across the 41 Samoan districts. To be noted is that, when the SSVI was first presented at the final stakeholder workshop, it was unequivocally consistent with the idea/perception of the dimensions of Samoa's social vulnerability already held by almost all of the experts (Fig. 2). AQ4

In particular, we set four SSVI categories (represented by gradient colours, paler to darker): low (0.33–0.40), mid (0.41–0.49), mid/high (0.50–0.58) and high (0.59–0.67).

The first category includes the districts with an SSVI ranging from 0.33 (Vaimauga West) to 0.40 (Lefaga and Falese'ela). The mid group ranges from 0.41 (A'ana North I) to 0.49 (Gagaifomauga II 0.48); the mid/high group from 0.50 (Gagaemauga II) to 0.58 (Gagaifoumauga III 0.57); and the high group from 0.59 (Vaisigano I) to 0.67 (Falealupo).

It is also possible to identify patterns of social vulnerability within the country by tabulating the values of the SSVI and of its four determinants—calculated as the averages of the respective districts' values—in the Samoan regions (see Table 2).

Social vulnerability patterns

The first consideration prompted by the assessment of the dimensions of social vulnerability carried out by means of the SSVI is that there is a sharp distinction, by and large consistent across determinants and indicators, between the two Samoan islands. The eastern island of Upolu, where the capital, the main port and the airport are located, presents a level of social vulnerability on average lower than that of the western island of Savai'i, characterized by an economy more dependent on subsistence agriculture and fishing. Another pattern that can be identified is that social vulnerability tends to increase in relation to the distance from Apia, despite the high values of 'economic welfare' largely determined by the relative greater inequality and the lower amount of remittances of Apia and North-West Upolu. Districts in the southern part of Upolu tend to have higher social vulnerability than northern ones, and those located at the extremes of the two islands show the same relationship. This aspect is evident in the spatial

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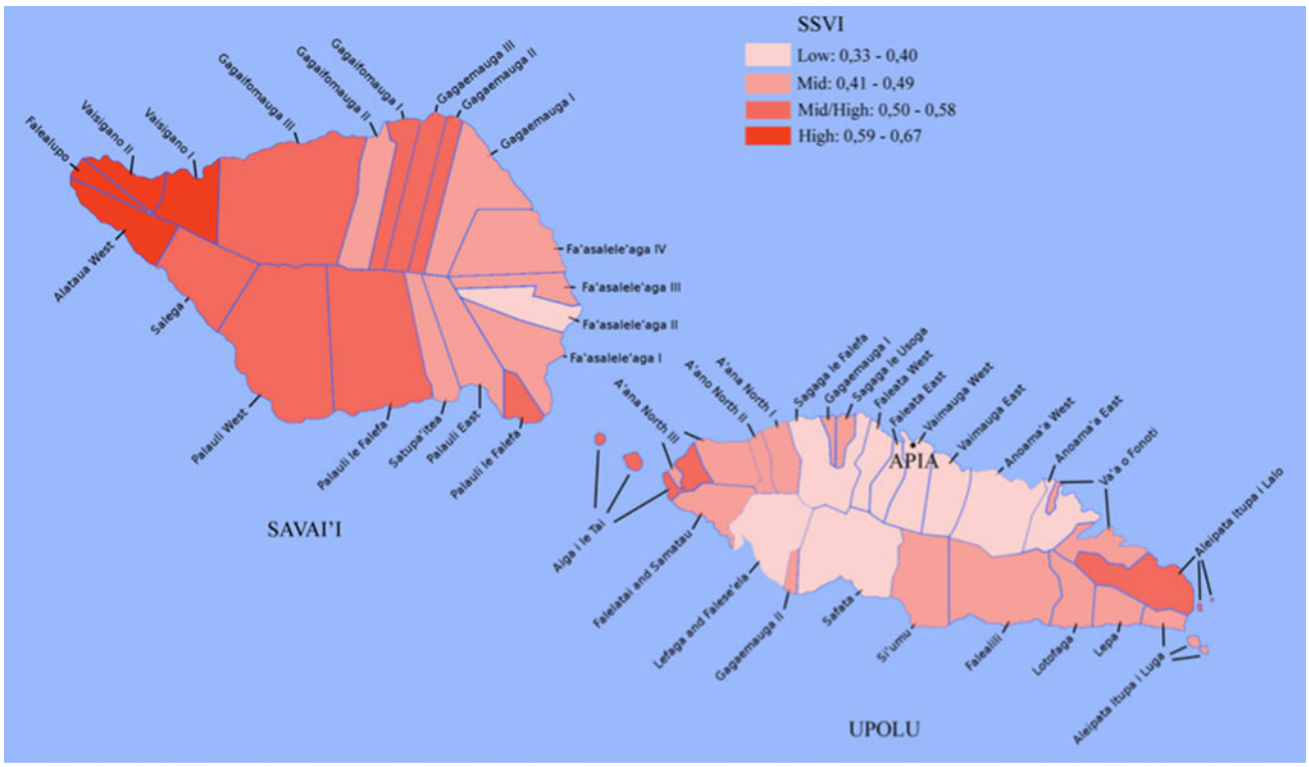

Fig. 2 Samoa SSVI map. Categories of SSVI values: low to high represented by *gradient colours*, paler to darker

AQ5 **Table 2** The SSVI and its determinants in Samoan regions

	SSVI	Economic welfare	Social well-being	Infrastructure and technology	Structure of the economy
Apia Urban Area	0.33	0.70	0.10	0.43	0.11
North-West Upolu	0.38	0.66	0.28	0.44	0.15
Rest of Upolu	0.47	0.55	0.58	0.43	0.32
Savaii	0.49	0.56	0.58	0.46	0.35
Samoa-Total	0.42	0.62	0.39	0.44	0.23

Source Authors' elaboration on the various sources reported in the last column of Table 1

distribution of social vulnerability, and it also captures two districts that seem to be anomalies in terms of the SSVI. The first is the district of Aiga I le Tai, which despite being in Upolu, belongs in the mid/high vulnerability group. The reason for this may be that most of the inhabitants of that district live on two small islands in the strait between Upolu and Savai'i, and they rely on the main islands for most services and goods. The second exception is the district of Fa'aselele'aga II, which, even though it is located on the island of Savai'i, has one of the lowest SSVI (0.34). This is very likely due to the strategic importance of the district, which is a major economic centre for Savai'i, where the port and the island's main facilities are located. Finally, on considering the highest and lowest values of vulnerability, we found that Apia has the lowest level of social vulnerability despite its higher population density; and that Falealupo, the most western village of the country, and which in 1991 was destroyed by the cyclone Val, has the highest value.

The contribution of determinants

From a different perspective, it is useful to consider the SSVI determinants in order to show the dynamics of social vulnerability and the strategic entry points for adaptation strategies. In this regard, it should first be noted that 'economic welfare' is consistently the largest contributor to social vulnerability, whereas the other determinants are more unevenly distributed across the Samoan regions. In particular, the significantly lower social vulnerability of Apia and its surroundings is largely due to the relatively low values of 'social well-being' and 'structure of the economy', whereas only the former is particularly penalizing for the rest of Upolu and Savai'i. This evidence seems to suggest that adaptation policy in the least

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vulnerable part of Samoa should focus primarily on 'economic welfare', whose increase should in any case be the priority goal of adaptation throughout all the Samoan regions (as made clear by the always larger magnitude of its values compared with those of the SSVI). By contrast, the lower values of the determinant 'structure of the economy' with respect to those of the SSVI in all regions testify that Samoa's economy, and especially its less vulnerable areas, can to some extent withstand the stresses brought about by climate change, given their relatively low relative significance of the most impacted sectors (agriculture, fishery and tourism). This situation seems indirectly to confirm that adaptation policies and projects should be addressed primarily to those vulnerable sectors, rather than being diverted to other more resilient segments of the Samoan economy.

Finally, the spatially uniform values of the determinant 'infrastructure and technology', the relatively low significance of its indicators and its consistency with the SSVI values demonstrate that this constituent does not contribute greatly to Samoan social vulnerability and that therefore it should not be a primary focus of adaptation initiatives in Samoa.

Discussion

Policy relevance

The policy relevance of the SSVI—or, better, of the detailed information on the dimensions of social vulnerability that it measures—and its application were among the main topics of discussion at both the one-to-one consultations and the final stakeholder's workshop. Consistently with the usual standpoints of, broadly speaking, policy evaluation analyses—i.e. prospective or ex ante and retrospective or ex post (Crabbè and Leroy 2008)—the two main possible policy uses identified for the SSVI and for its determinants were, as anticipated: (1) ex ante tools with which to prioritize areas for the implementation of adaptation policies and projects; and (2) ex post-evaluative tools with which to assess the effectiveness of adaptation policies and projects (and, in the case of major adaptation initiatives, also to monitor their evolution during the project's realization, i.e. an ongoing form of ex post evaluation). Indeed, both uses of the SSVI should be primarily targeted on the natural and socio-economic systems most exposed and sensitive to climate impacts: in the case of Samoa, as pointed out in the first section, these are water, biodiversity, forests, coastal areas and infrastructures, tourism and human health.

In regard to (1), national and international institutions, and private donors interested in a fair and effective implementation of adaptation policies and projects can use the outcomes of a social vulnerability assessment carried out through the SSVI as a prima facie discriminant to channel funds towards those areas/communities/sectors that need priority intervention. During the final stakeholder workshop, some of the representatives of development agencies remarked that being able to identify and target the most vulnerable areas would be crucial for maximizing the fairness and effectiveness of funds disbursement. On the other hand, other agency representatives and some officials from the Samoan ministries expressed concerns regarding this potential role of the SSVI. Their main argument was that basing policy decisions on an index that provides a constructed idea of social vulnerability could be misleading, whereas these decisions should be made on a case-to-case basis. All in all, however, an interesting insight arose during the one-to-one consultations, when a ministry official recognized that the use of the SSVI could provide an objective basis for choosing how to allocate adaptation funds, since such decisions, he argued, are often made on a political basis that disregards any objective considerations/information.

As for point (2), similar to what recent works (IIED 2013) have stressed, vulnerability indices can have a valuable role in assessing the effectiveness of adaptation policies and projects. Stakeholders, both ministry officials and development agency representatives, expressed their interest in the application of the SSVI to evaluate and monitor activities, since most of the assessments currently carried out focus on processes and almost completely disregard the outcomes of adaptation strategies. Moreover, some stakeholders pointed out that the SSVI would be significant for them only if it were measured every year, so that it furnished information about the variability over time of the dimensions of social vulnerability. Other participants highlighted that the index should be tailored for different sectors and that its multidimensional approach could be an obstacle to the shaping of specific policies.

Consequently, we conclude that the SSVI may not be particularly useful for determining adaptation policy-making *tout court*. In fact, the stakeholder consultations made it clear that a multidimensional assessment of social vulnerability intended to provide decision-makers with policy-relevant information should not run the risk of over-aggregation. Rather, a 'fine-grained' perspective would require the SSVI's disaggregation into its determinants, whose measurement could then be used as yardsticks both to define and, to some extent, assess adaptation policies and projects. The scope of, and the rationale for, a multidimensional assessment of social vulnerability based on a composite index lies mainly, in our opinion, in the evidence yielded by the measurement of the SSVI determinants. When linked with the objectives and ends of

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adaptation policy, the SSVI determinants calculated can, in fact, disclose a great deal of information and suggest novel and insightful lines of action for decision-makers.

Potential of the extension of the SSVI to the Pacific Islands

Environmental issues are usually settled through appropriate decentralized solutions, since benefits and costs are by and large clearly specified and confined to specific areas (Oates 2001). Climate change is a different matter, however, because it is emissions by sources throughout the world that cause the concentration of greenhouse gases (GHG) in the atmosphere and the consequent alterations of climatic systems that bring about harmful impacts. While mitigation, given the global public good nature of climate stability, should be in principle undertaken at global level, adaptation—the domain of this article—entails different considerations. Adaptation, in fact, provides local, national and regional public goods. At the same time, the common exposure and sensitivity to climate change and the kindred socio-economic conditions of the Pacific Islands, coupled with the circumstance that most climate impacts affecting the region (and not only the expected ones, but also abrupt events), are unlikely to remain confined within the boundaries of one country, characterize adaptation in the South Pacific as mostly a regional public good. Accordingly, regional collective action to counter climate impacts is necessary since the adaptation needs of Pacific Islands can be more successfully addressed on a regional scale (Grasso 2006). This level of action engenders proximity benefits such as closer interaction and learning, lower transaction costs and co-benefits from many actions.

In this regard, the adoption of the SSVI by Pacific Islands would provide the common basis for informing regional adaptation strategies and for building a process of 'bounding' (Newman 2003) which would favour the establishment of a 'community of place' (Pelling and High 2005) irrespectively of national boundaries. In other words, the sharing of the same likely climate impacts and of similar sensitivity and socio-economic characteristics makes it possible to rely on common regional parameters of the dimensions of social vulnerability (measured through the SSVI) that can facilitate a mutual closeness among Pacific Islands which might be the foundation for the emergence of a regional community in regard to climate change much more effective in dealing with the requisite adaptation strategies at both a regional and national/local scale.

Given the underdevelopment and the poverty so endemic in the South Pacific, it is essential to empower Pacific Islands societies by fostering institutional and governance capacities. We claim that an approach to regional adaptation facilitated by, and interwoven with, the common language offered by the adoption of the SSVI for measuring the dimensions of social vulnerability, would ultimately enable Pacific Islands, despite their somewhat divergent interests, to conceive more transparent and coherent adaptation to climate change based on common views and greater mutual trust able effectively to address a significant part of their most pressing socio-economic urgencies.

Conclusions

The South Pacific region is in a highly unfair situation; in particular, the Pacific Island countries bear a disproportionate burden of the impacts of climate change. Although the SSVI cannot be the ultimate (ex ante and/or ex post) tool with which to choose how to allocate adaptation funds and to appraise the effectiveness of adaptation strategies, it has the ability to track the dimensions of social vulnerability over time and across territorial areas. This makes the index one of the main instruments able to support decision-making in adaptation to climate change and, ultimately, a promising means with which effectively to address adaptation needs locally and on a regional scale, as well as being an informative planning tool for future adaptation strategies.

In short, the assessment of social vulnerability carried out through the SSVI shows that the most vulnerable districts of Samoa are those with lower income levels, less access to public services and greater dependence on riskier sectors. Furthermore, on different grounds, we claim that the SSVI can play a prominent role in the Pacific Islands for two reasons. First, the measure of the dimensions of social vulnerability provided by the SSVI makes it possible to rethink adaptation policies and eradicate one of the main factors impeding their effectiveness in the South Pacific region. In fact, the SSVI, by decomposing the complex structure of social vulnerability and highlighting the main and diverse entry points for reducing it, blurs the artificial and counter-productive distinction between disaster risk reduction and climate change adaptation that still largely characterizes efforts against climate change in the South Pacific region, and forces decision-makers to focus on specific initiatives to counter harmful climate impacts, primarily in the more exposed and sensitive natural and socio-economic systems. Second, this sharper focus coupled with the detailed information provided by the SSVI on the dimensions of social vulnerability permit closer specification of the adaptation strategies required at different territorial levels, from regional to communitarian, and with regard to the latter, to help develop community-based adaptation strategies. In fact, the SSVI-based assessment of

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social vulnerability can more effectively identify the specific needs for investments in enhancing livelihoods, development planning, disaster preparedness, and increasing the resilience of weakest households that should inform the consequent responses.

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