Rev Reg Res
https://doi.org/10.1007/s10037-020-00142-7

ORIGINAL PAPER

Livelihood vulnerability in Tambak Lorok, Semarang: an assessment of mixed rural-urban neighborhood

Mega Febrina Kusumo Astuti[1] · **Wiwandari Handayani**[1]

Accepted: 25 July 2020

Abstract Rural and urban types of livelihood are widely different. Rural livelihood refers to human dependence on natural resources, while urban livelihood mostly focuses on urban poverty in which natural resources are regarded as a less significant asset. Tambak Lorok, the largest fishing village in Semarang, Indonesia has a unique combination of urban–rural livelihood characteristics. The rural features are indicated by household dependence on natural resources and low educational level of the head of family, while the urban characteristics are indicated by easy access to various infrastructural services. Accordingly, this study aims to assess livelihood vulnerability in Tambak Lorok as a unique mixture of characteristics between urban and rural neighborhoods. Livelihood vulnerability index (LVI) measurement and factor analysis were applied to assess the level of vulnerability and identify the main factors that affected vulnerability at the household level. The result of LVI assessment indicates that residents in the area have low capabilities to cope with their uncertain sources of income due to their limited capacity. They cannot optimize the potential of their proximity to urban services.

Keywords Urban livelihood · Rural livelihood · Vulnerability · Household capability

✉ M. F. K. Astuti
mega.febrina18@pwk.undip.ac.id

W. Handayani
wiwandari.handayani@pwk.undip.ac.id

[1] Department of Urban and Regional Planning, Diponegoro University, Prof. Soedarto Street, Tembalang, 50275 Semarang, Central Java, Indonesia

Published online: 11 August 2020

Vulnerabilität des Lebensunterhalts in Tambak Lorok, Semarang: Bewertung einer gemischt ländlich-urbanen Nachbarschaft

Zusammenfassung Lebensgrundlagen in ländlichen und städtischen Räumen sind sehr unterschiedlich. Während die Lebensgrundlage in ländlichen Räumen von natürlichen Ressourcen abhängt, beziehen sich städtische Lebensgrundlagen hauptsächlich auf städtische Armut, in welchem Zusammenhang natürliche Ressourcen als weniger bedeutsam betrachtet werden. Tambak Lorok, das größte Fischerviertel in Semarang, Indonesien, verfügt über eine einzigartige Kombination von städtisch-ländlichen Lebensbedingungen. Die ländlichen Charakteristika sind durch die Abhängigkeit der Haushalte von natürlichen Ressourcen und dem geringe Bildungsniveau der Familienoberhaupte geprägt, während städtische Merkmale durch den leichten Zugang zu verschiedenen Infrastrukturdienstleistungen gekennzeichnet sind. Entsprechend zeigt diese Studie, dass die Vulnerabilität von Livelihoods in Tambak Lorok durch eine einzigartige Mischung ländlicher und städtischer Nachbarschaftsmerkmale geprägt wird. Eine Messung des Livelihood Vulnerabilitätsindex (LVI) und eine Faktorenanalyse wurden angewandt, um den Grad der Vulnerabilität zu bewerten und die Hauptfaktoren zu identifizieren, die die Vulnerabilität auf der Ebene der Haushalte beeinflussten. Das Ergebnis der LVI-Bewertung zeigt, dass die Bewohner des Untersuchungsgebiets aufgrund ihrer begrenzten Kapazitäten nur wenig in der Lage sind, mit ihren unsicheren Einkommensquellen umzugehen. Sie können das Potenzial ihrer Nähe zu städtischen Dienstleistungen nicht optimal nutzen.

Schlüsselwörter Städtischer Lebensunterhalt · Ländlicher Lebensunterhalt · Vulnerabilität · Haushaltsfähigkeit

1 Introduction

Vulnerability assessment has been regarded as an important tool in the past decade due to the fact that climate change and hazards frequently occur at a global scale and have created impacts at the local scale (Handayani et al. 2017). Such assessment evaluates conditions of a system that may collapse due to exposure to hazard (Adger 2006; Turner et al. 2003). Not only it is understood as the severity of hazard to which a number of people or assets are exposed to, but also as a reflection on the susceptibility of people and their assets to loss and damage (Prevention Web 2015). Füssel (2007) presented two factors that caused vulnerability, which originated from internal and external systems. Internal factors refer to causes in relation to the system or community itself, while external factors refer to 'something' outside of the system. Furthermore, vulnerability is described as exposure of the system towards external factors, its sensitivity and capacity to adapt during disruptive events (Adger 2006).

Livelihood is an important element in vulnerability assessment as it includes socio-economic attributes of people living in a high risk area. Livelihood is a complex system that involves people, human activities, assets, and gains or outputs required by humans to ensure that their basic needs are fulfilled (Organization of Ameri-

can States 2015). Vulnerability of livelihood should be assessed comprehensively through indicators such as the livelihood vulnerability index (LVI), which was developed by Hahn et al. (2009). The ability of LVI to draw out subtle yet critical differences in specific vulnerabilities (e.g., related to water, food, and other factors) is valuable in tailoring policies that can meet the needs of resource-dependent communities in developing countries (Shah et al. 2013). LVI integrates vulnerability assessment and climate exposure as well as accounts for household adaptation practices to comprehensively evaluate livelihood risks resulting from climate change (Hahn et al. 2009). The study incorporates six components (climate variability, natural disasters, socio demographic profile, adaptive capacity, health, and food and water resources) that are compatible with the issues in Mambote and Moma districts in Mozambique. To assess vulnerability differences among wetland communities in Trinidad and Tobago, Shah et al. (2013) modified LVI by presenting new components: housing and land tenure, as well as livelihood strategy social network (Shah et al. 2013). Basically, components of LVI enable adjustments to apparent issues in the study area. The design is flexible and thus development planners can refine and focus their analyses to suit the needs of each geographic area (Hahn et al. 2009).

Previous studies of livelihood have commonly focused on rural areas where household agriculture is the main source of livelihood. Chambers and Conway (1992) provided a concept of livelihood strategy adopted from peasant strategy, famine coping strategies, and agriculture. Rudiarto et al. (2019) assess rural coastal livelihood in various dimensions showcasing the fishery sector. Ellis (2000) examined rural livelihood diversity and presented livelihood diversification focusing on rural areas. The notion of rural livelihood is identical to agricultural activity, with the understanding that agricultural households adopt livelihood strategies such as extensification, intensification, diversification, and migration as a response to climatic and other stressors (Paavola 2008). In addition, Brenner and Pflitsch (2017) concluded that livelihood appeared as a topic of discussion in most scientific publications on sustainable agriculture and social systems. Interrelation between livelihood and rural area has caused the livelihood perspective to become central to rural development thinking and practice (Scoones 2009).

Urban livelihood is rarely associated with community dependence on natural resources. Urbanization leads to commercialization and modernization, which then conduce a transition from agricultural to industrial employment and particularly, to service-sector jobs (de Haan 2017). Natural resources are a less significant asset in urban livelihood, where the economy is characterized by a greater degree of commercialization, and where most basic goods, such as food and housing, should be purchased or paid forand therefore those living in the urban areas will have to generate more income than most rural households to survive (Meikle et al. 2001). As a consequence, labor undoubtedly becomes the most important asset for urban households as they cannot depend on natural resources. Households in an urban areas often face several obstacles due to the lack of job opportunities, lack of access to loans, and high municipal taxes for formally registered activity (Maxwell et al. 2000). Education, skills, health, the ability to work and social relations are important assets for such individuals/households to secure jobs and earn their living (Maxwell et al. 2000; de Haan et al. 2002; Schütte 2005).

Considering these two concepts of livelihood, we expect that a combination of the urban and rural livelihood characteristics exists in Tambak Lorok-a '*kampung*' (urban-village) located at the coastal area in Seemarang. Coastal areas are particularly vulnerable, not only because they are high exposurely to climate events but also because communities living in these areas depend on natural resources as their main source of living. Both the people and the location are susceptible to natural disturbances such as coastal storms and erosion, which pose significant threats to coastal physical, economic, and social system (Bevacqua et al. 2018). Livelihoods of coastal communities are strongly linked to the health of marine ecosystems, as a majority of their occupations rely on the fisheries sector (Salafsky and Wollenberg 2000). In addition, global trends show that human populations in coastal areas are increasing as a result of migration, which also causes environmental degradation and escalates living risks for those in coastal areas (Ferrol-Schulte et al. 2013). Community livelihood becomes an important topic in the context of coastal vulnerability, as it reflects in critical factors that influence the vulnerability or strength of individual or family survival strategies (Allison 2005).

As the largest fishing village in Semarang, Tambak Lorok depends on natural resources, with its economic activity focusing on the fisheries sector. Tambak Lorok can be classified as a rural area even though it is administratively located in an urban area. This phenomenon is interesting because the community livelihood in Tambak Lorok is influenced by urban activities, which makes the community different from a common rural community. Thus, the unique livelihood in Tambak Lorok needs to be explored further. In this study, we focused on the context of vulnerability as an important issue in Tambak Lorok.

This study aims to assess livelihood vulnerability in Tambak Lorok to represent a unique mixture of characteristics between urban and rural neighborhoods. We conducted two main analyses to identify livelihood vulnerability. First, LVI assessment was applied to identify livelihood conditions through a household perspective without adopting main components provided by Hahn et al. (2009). In this study, LVI assessment is focused on identifying rural-urban characteristics so that the main components are emphasized on the element of livelihood itself. Researchers have modified the main components based on indicators of livelihoods presented by Chambers and Conway (1992) i.e. Livelihood Capabilities, Claims and Access, Stores and Resources. Other main components determined by general issues in Tambak Lorok, such as their exposure to climate and natural disasters, as well as socio-demographic sensitivity within the community. Second, statistical analysis is used to identify the most influential factors that contribute to vulnerability level. By focusing on some key factors, it will be easier to generate a conclusion (Yong and Pearce 2013).

2 Study area

Tambak Lorok is vulnerable to the impact of climate change (Mulyana et al. 2013). Located on the coast of Semarang City, the area is exposed to tidal flooding and sea level rise. The situation is worsened by land subsidence. Tidal flooding occurs

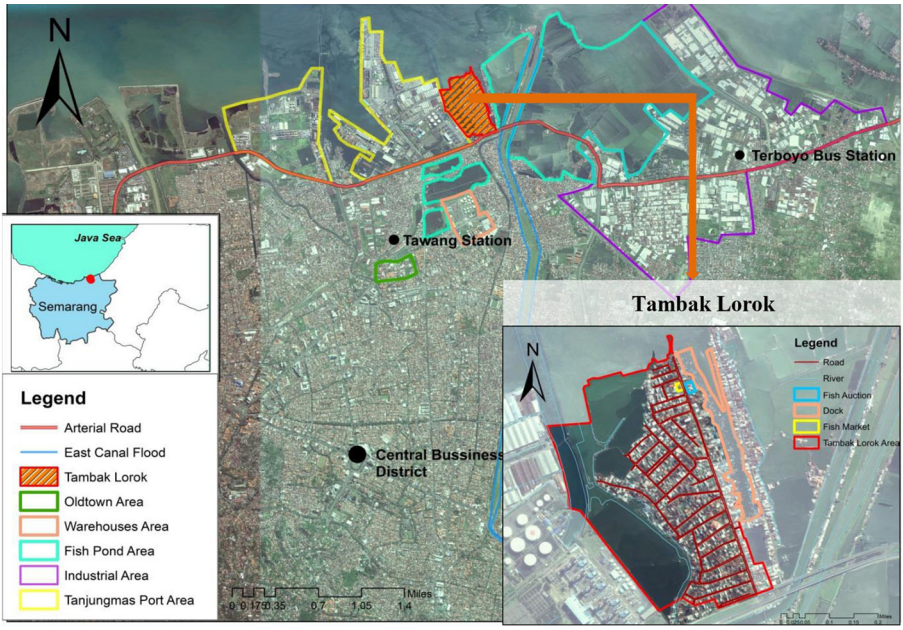

Fig. 1 Tambak Lorok Administrative Area

at an altitude of 40–45 cm almost every year, affecting an area of 16.02 hectares (Ministry of Public Work 2017). Sea level rise was identified at 6–10 mm per year. Additionally, Tambak Lorok lies above young alluvium deposits, leading to a rate of land subsidence of up to >10–13 cm/year (100 Resilient Cities 2016), which exacerbates sea flooding. Moreover, rainfall anomaly occurred four times between 2001–2015 caused flooding in several locations (BAPPEDA Semarang City 2019), which also affected Tambak Lorok. Located near from downstream of Barang River, Tambak Lorok often hit by downstream floods. Sejati et al. (2019) further revealed a 36.14% decline in the vegetation canopy in Semarang City, including in Tambak Lorok, resulting in surface temperature increase of 2–5 °C on average.

As the largest fishing village in Semarang City, Tambak Lorok plays an important role in the region's fisheries sector. The village is located in a strategic area as it is very close to the port, central train station, and big industrial zones (See Fig. 1). Accordingly, a majority of the community members work not only in the primary sector as fishermen and fish traders but also the secondary and tertiary sectors as blue collars workers in the neighboring industrial zone and port (Ministry of Public Work 2017). Table 1 describes the basic socio-economic characteristics of Tambak Lorok community.

The Tambak Lorok neighborhood is categorized as a slum area inhabited by poor families. Of the total population, 46.3% is categorized as poor (Ministry of Public Work 2017), which means that their income is below the regional minimum wage (2.3 million rupiah/168.15 USD). A slum area is characterized by the lack of sanitation, absence of waste disposal system, and damaged infrastructures (including

Table 1 Socio-Economic Characteristics of Tambak Lorok. Source: Artha Nugraha (2017); Ministry of Public Work (2017)

Socio-Economic Characteristics	
Total population	8252 people
Total households	2032 households
Density	218.4 people/ha
Number of low-income households	3823 people/942 households (46.3% of the total population)
Average income	1–2 million rupiah (73.60–147.38 USD)
General occupations	42% of the total population are self-employed and labors (fish sellers, seafood processors, factory workers, port workers, casual labors)
	25% of the total population are fishermen. 87% of fishermen in Tanjung Mas region live in Tambak Lorok (Tanjung Mas is a subdivision of Semarang, of which Tambak Lorok is a part of it)
	31% of the total population are unemployed
Main economic activity	Fisheries sector

drainage channels, roads, and service buildings) as a result of tidal flooding and land subsidence. However, there are several important infrastructures to support fishery sector in the area, such as fish markets, fish auction facilities, docks, and fishponds (Purwanto et al. 2017).

3 Methods

The calculation of livelihood vulnerability level involves two stages. First, we used the LVI method to assess livelihood vulnerability based on the indexed six main components and 29 subcomponents. Second, factor analysis was done to identify the most influential factor to livelihood vulnerability.

3.1 Data collection

This study employed quantitative design to assess livelihood vulnerability and collected vulnerability data based on household perspectives on their experience with disaster and livelihood. A questionnaire was used as a data collection instrument and distributed evenly among 334 household respondents. The number of questionnaires was determined by quota sampling adjusted to the total population in Tambak Lorok and the respondents were randomly assigned. Based on the survey results, the samples show various characteristics that are representative to this study. There are no specific criteria for the respondents. It is important to capture the conditions in each household as a whole in order to identify whether their livelihood tends to have urban or rural characteristics.

3.2 Livelihood vulnerability index

This method was used to assess household perspectives on the level of livelihood vulnerability through an index assessment of the main components and their subcomponents via several calculation steps. The data collected were purely from the household perspectives to more deeply reflect the community members' experience in regards to exposure to disturbance, sensitivity and their capacity to survive. LVI calculation was based on weighted average, balanced on each main component and subcomponent. Standardizing the index of each subcomponent was necessary because various data were used. The Human Development Index is a formula that standardizes each index (Hahn et al. 2009) and is calculated based on the following equation:

$$\text{Index}_{Sd} = \frac{S - S\text{min}}{S\text{max} - S\text{min}},$$

where S is the original subcomponent value, and Smin and Smax are the minimum and maximum values for each subcomponent. For example, the percentage of households that has experienced flooding was 17.10% of the total population. The values of this subcomponent ranged from 0 (minimum) to 100 (maximum), and they were used to convert the original subcomponent into a standardized index. The result of this calculation wass 0.171 for household perspectives to flooding and could be integrated into other standardized subcomponents, which further contributes toward main component indices calculation. The calculation of each main component wass based on the following equation:

$$M = \frac{\sum_{i=1}^{n} \text{Index}_{s_i}}{n},$$

where M is the index of main components (natural disasters, climate variability, sociodemographic profile, livelihood capabilities, claim and access, and stores and resources). Index_{s_i} represents the subcomponent, where i indicates the subcomponent and n is the number of subcomponents. The average value of all main components was used to calculate LVI level based on the following equation:

$$LVI = \frac{\sum_{i=1}^{n} W_{M_i} M_i}{\sum_{i=1}^{n} W_{M_i}},$$

where W_{M_i} is determined by the number of subcomponents that make up each major component. This calculation resulted in indices ranging from a minimum of 0 (less vulnerable) to a maximum of 1 (more vulnerable).

Appropriate main components for the issues in this study area should be incorporated to assess vulnerability index. In a previous study, Hahn et al. (2009) employed six main components that were specifically adjusted to the characteristics and sensitivity aspects of two rural areas. In this study, LVI assessment was focused on identifying rural-urban characteristics and therefore the main components were emphasized on livelihood itself. Therefore, we modified the main components by adopting only parts of the main components provided by Hahn et al. (2009). Natural

Table 2 Design of Livelihood Vulnerability Index

Main components	Subcomponents	Descriptions
Exposure		
Natural Disasters	Household perspectives on flooding and tidal flooding	Percentage of households that have experienced flooding
		Percentage of households that have experienced tidal flooding
Climate Variability	Household perspectives on temperature rise	Percentage of households that have experienced temperature rise
	Household perspectives on rainfall patterns	Percentage of households that observed a change in rainfall patterns
	Household perspectives on extreme climate	Percentage of households that have experienced extreme climate
	Household perspectives on sea level rise	Percentage of households that have experienced the impact of sea level rise
	Household perspectives on climate change impact	Percentage of households that have experienced climate change impact on income
		Percentage of households that have experienced climate change impact on occupations
		Percentage of households that have experienced climate change impact on health
Sensitivity		
Sociodemographic Profile	Dependency ratio	Ratio of non-productive residents (0–14 years and >64 years) to productive residents (15–64 years)
	Number of poor families	Percentage of households which income is lower than the regional minimum wage (*UMR*)
	Female household heads	Percentage of households with a female head of family
	Household heads aged >64 years old	Percentage of households with a head of family that is >64 years old
	Direct/Non-direct users	Percentage of heads of family whose jobs are dependent on the primary sector
Adaptive capacity		
Livelihood Capabilities	Education level of head of household	Percentage of household heads with low educational level (below upper middle school)
	Household diversification	Percentage of household heads that have a single job
	Number of family members that have an occupation	Ratio of the number of working family members to the number of family members that are unemployed
	Number of households consisting of more than one family	Percentage households with a sole family unit

Table 2 (Continued)

Main components	Subcomponents	Descriptions
Claims and Access	Social support (in the event of a disaster)	Percentage of households that have not received support from the government and neighbors when a disaster occurs
	Social support from the government	Percentage of households that have obtained social support from the government
	Household involvement in community activities	Percentage of households that have not been involved in social activities
	Household participation in local planning	Percentage of households that have not been involved in planning process
	Access to loan	Percentage of households that have no information on where to borrow money
		Percentage of households that are unable to access loans
	Access to electricity	Percentage of households that have no access to electrical network
	Access to educational facilities	Percentage of households that are far from elementary schools (>6000 m)
		Percentage of households that are far from junior high schools (>6000 m)
		Percentage of households that are far from high schools (>12,000 m)
	Access to health facilities	Percentage of households that do not receive assistance for health insurance
		Percentage of households that are far from health facilities (>12,000 m)
	Access to information	Percentage of households with noaccess to information (internet, telephone, newspaper, television, and others)
	Access to clean water	Percentage of households with no proper access to clean water
	Access to transportation	Percentage of households with no access to public transportation
Stores and Resources	Savings ownership	Percentage of households with no savings
	House ownership	Percentage of households with no home ownership certificate
	Land ownership	Percentage of household with no land ownership certificate

disasters and climate variability are suitable components for Tambak Lorok, and sociodemographic profile is still used to represent the general demography of the community. Tambak Lorok is located in an urban area with diverse conditions and therefore the main components were not determined as a specific asset. We selected three other main components, i.e. livelihood capability, claim and access, as well as stores and resources, which were some livelihood indicators included in the work of Chambers and Conway (1992). These are more flexible indicators of livelihood assessments included in the urban or rural characteristics. Then, 29 subcomponents were established to explain the main components in detail and were adopted in considering local problems. The main components and subcomponents are further explained in Table 2.

3.3 Factor analysis

This research used large data of several variables, which may hinder the derivation of conclusions. It would be easier to focus on a limited amount of key factors rather than having to consider many variables that may be trivial (Yong and Pearce 2013). Considering the complexity of livelihood vulnerability assessment, using factor analysis we identified components that have a large contribution to vulnerability level. Factor analysis is a statistical approach used to analyze the relationships between variables and explain variables in the same dimension (Hair Jr et al. 2010). In this analysis, measurable and observable variables can be reduced to those that share a common variance and are unobservable (Bartholomew et al. 2011); in other words, reducing dimensionality (Yong and Pearce 2013). Principal component analysis was used to simplify data by identifying relationships between variables that were mutually independent. A simple mathematical model of factor analysis is:

$$X_j = a_{j1}F_1 + a_{j2}F_2 + a_{j3}F_3 + \ldots + a_{jn}F_n$$

Where X denotes the variables, and F represents the factors.

Factor analysis was conducted through SPSS V17.0 software. Data validity was tested based on: (1) Kaiser-Meyer-Olkin test; (2) Bartlett Test of Sphericity and Measure Sampling Adequacy test; and (3) Extraction values, with the following explanations:

1. **Kaiser-Meyer-Olkin** test was done to measure sampling adequacy, which was represented by the proportion of observed correlation and partial correlation coefficient. High values (close to 1.0) indicated a high correlation among variables, while lower values indicated less correlation. Any variables with a coefficient value of less than 0.5 were removed, then the remaining variables were retested.
2. Correlation matrix was measured using the **Bartlett Test of Sphericity** and **Measure Sampling Adequacy (MSA) Test**. Bartlett's test Sphericity was used to ensure that the variable dimensions are simpler and more useful without losing much of the previous information. A value of close to 0.000 in the Bartlett Test of Sphericity indicated a significant value of the datasets that is suitable for a data reduction technique. Meanwhile, MSA test was used to assess the inter correlation

among variables and the suitability of factor analysis. MSA values greater than 0.5 showed that the variables are strongly correlated.

3. **Extraction** values in the Communalities Table represented the characteristics of each variable. Any variables with an extraction value of less than 0.5 were removed from further analysis.

4 Livelihood vulnerability assessment

Table 3 shows the LVIs for six main components and 29 subcomponents. The table indicates that three main components (natural disasters, climate variability, and livelihood capabilities) have an index of more than 0.5, while three others (sociodemographic profile, claim and access, and stores and resources) have an index of below 0.5. Livelihood capabilities have the highest index (0.714), whereas claims and access have the lowest index (0.221). Overall, the total LVI is 0.405, which is categorized as moderate level vulnerability.

Fig. 2 shows the index value of each component. As mentioned, in this study, livelihood vulnerability assessment focuses on the index of each component. We included several findings from our surveys and used secondary data to explain the results of the LVI calculation.

Livelihood capabilities have the largest index, which indicates that the households have low capacity to cope with shocks and stresses. This component consists of a list of sub-components related to the social conditions of households that represent their ability to withstand any disturbance and make a living. All subcomponents of livelihood capabilities have a large index value, in which the low-educated household heads have the largest index. The importance of formal academic education and skills in the workplace to improve livelihoods prospects and alleviate poverty are closely related to the low level of education and lack of skills (Ellis 1999). Improving the skills and education levels of the household head or the breadwinner can possibly get the family out of poverty, i.e., the inability to mobilize resources required to deal with shocks or chronic low-income situations (Cinner 2011).

Another subcomponent, Diversification, has a larger vulnerability index (0.662), with 66.20% household heads with no diversified jobs, respectively. It is means only 33.80% of the household heads diversified jobs. Diversification is described as any efforts to earn income from more than a single job. In Tambak Lorok, there is a trend in which fishermen work as construction laborers or unskilled laborers in the event tha weather conditions prevent them from fishing, when the neighborhood is exposed to tidal flood, or when their catch rates are low. Meanwhile, those who are employed in the non-primary sectors (jobs in construction, service sectors, and trade) rely on marine resources for their side jobs. People expect to earn additional income through fishing when they have not been recruited for a project.

All household members in Tambak Lorok are likely to contribute in earning income for the family. For example, children may be involved in fishing, while women in the community help process and sell fish, as well as make fish dumplings (Sari and Hadi 2018). Such instances demonstrates the capacity of households to improve the quality of their livelihoods by diversifying and empowering family

Table 3 Livelihood Vulnerability Indices representing households in Tambak Lorok

Main Components and Subcomponents	Index
Natural Disasters	*0.584*
Households that have experienced flood	0.171
Households that have experienced tidal flooding	0.997
Climate Variability	*0.67*
Household perspectives on temperature rise	0.868
Household perspectives on change in rainfall patterns	0.710
Household perspectives on extreme climate conditions	0.284
Household perspectives on sea level rise	0.916
Household perspectives on climate change impact	0.573
Sociodemographic Profile	*0.267*
Dependency ratio: proportion between non-productive (0–14 years old and >64 years old) and productive residents (15–64 years old)	0.213
Number of poor families (household income lower than regional minimum wage)	0.338
Female household head	0.123
Head of household aged >64 years old	0.147
Household dependency on natural resources (household occupation in primary sector)	0.512
Livelihood Capabilities	*0.714*
Low-educated household heads (below upper middle school)	0.814
Household heads that have a single job (diversification)	0.662
Comparison between number of working and non-working family members	0.692
Single family in one household	0.689
Claims and Access	*0.221*
Communities that did not receive support from the government and neighbors when disaster occurred	0.636
Households that are not involved in social activities	0.018
Households with no participation in community planning	0.79
Households with no access to loans	0.249
Households with no access to electricity	0.039
Households with no access to schools	0.206
Households with no access to health facilities	0.229
Households with no easy access to information	0.000
Households with no access to clean water	0.042
Households with no proper access to transportation	0.000
Stores and Resources	*0.278*
Households with no have savings	0.683
Households with no house ownership	0.078
Households with no land ownership	0.075
Total LVI	*0.405*

members to work. Furthermore, this proves that individuals with more than one jobs, or who works in the household with other individuals those who contributes to earning income for the household, are able to cope with decreased productivity or the loss of livelihood (Lohmann 2016). According to this study, the number of households with low capability exceeds those with high capability. In addition,

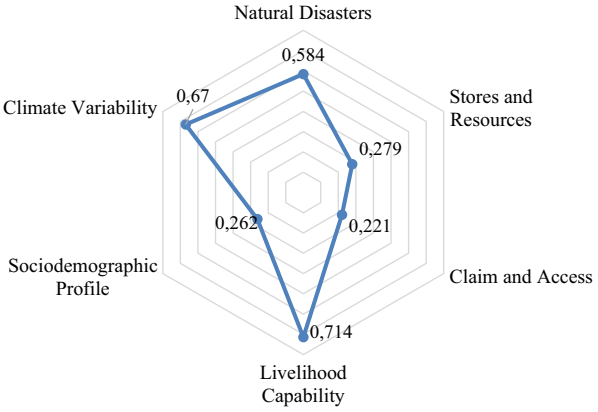

Fig. 2 Indices of Livelihood Vulnerability Components

livelihood capability represents efforts to save households from poverty (Shah et al. 2013). A low livelihood capability leads to difficulties in escaping poverty, which in turn increases livelihood vulnerability. Poverty is not only limited to the lack of money, but also to the inability to meet basic needs, poor living standard and the lack of means for empowerment (Akindola 2009).

Exposure to natural disasters is measured based on household perspectives on flood and tidal flooding. Based on the survey results, 17.07% of the households are exposed to flood and 99.7% are exposed to tidal flooding. Tidal flood frequently occurs in Tambak Lorok due to the fact that it is directly adjacent to the Java Sea. The average height of tidal flood goes to 40–45 cm for up to 3 h (Ministry of Public Work 2017). Flood and tidal flooding are external factors within the biophysical domains (Füssel 2007) which made households vulnerable. Both natural disasters hamper economic activity, and cause property damage as well as loss of assets. This makes it difficult for households to earn income. Tidal flooding is also closely related to land subsidence. Semarang experiences land subsidence of 5.9 cm per year due to natural consolidation of young alluvium soil, extraction of ground water, and high building and infrastructure loads (Abidin et al. 2013). The pressure of urbanization in Semarang can exacerbate tidal flooding and land subsidence. As tidal flooding is a complex problem, to solve it the socio-ecological system should be involved.

The climate variability component measures household perceptions on the level of exposure to climate variability. Households in Tambak Lorok are highly exposed to sea level rise, rising air temperatures, and changes in rainfall patterns, which are all interrelated conditions. Rising global temperatures due to greenhouse gases causes' climate change and sea level rise and it also felt at the local level. In Tambak Lorok, sea-level rise is expected to reach 15.5 cm in 2030 (Ministry of Public Work 2017). The sociodemographic component measures the sensitivity of vulnerable groups with higher livelihood risks during shocks and stresses. The sociodemographic component refers to certain population groups that have limitations when exposed to shocks and stresses. Vulnerable groups are sectors of the population that pose similar behavior patterns, and tend to be victims of danger (Downing et al. 2005). The sensitivity level of Tambak Lorok community is strongly influenced by

the types of work and number of poor households. Meanwhile, the sensitivity levels for dependency ratio, percentage of female household head, and percentage of household heads aged >64 years old are not extremely high, but they do influence the level of sociodemographic sensitivity.

Furthermore, 48.8% of the population works in primary sector, which are exposed to tidal flooding and sea level rise. These conditions cause environmental damage and can potentially damage ponds as well as inhibit sailing and fish trading activities, thereby causing a reduction in household income. In addition, the number of poor households in Tambak Lorok has reached 33.83%. Poor households are defined as those which total income is lower than Semarang's regional minimum wage (2.3 million Rupiah/168.15 USD). Tambak Lorok community members generally work in the informal sectors and have low skills, which is the reason for their low salaries and daily income uncertainty.

Claims and Access shows a low vulnerability level, which means that the households have received assistance from the government and society, and can access services provided by the government, such as access to electricity, clean water, education, and health. Based on the survey data, Tambak Lorok community members have easy access to urban facilities because the area is located within the urban administration.

The rapid development of information technology and the provision of a good transportation system by the city government have facilitated community's access to information and transportation. In addition, 96% of the households have proper access to electricity, while the rest access electricity through illegal channels connected to their neighbors' electricity network. Among the households, 95.8% have proper access to clean water. According to our survey, there are three sources of clean water: Perusahaan Daerah Air Minum (a local water company), deep wells (artesian well), and water vendors. Generally, people use clean water sources from artesian wells that are used jointly by community members within each neighborhood. Access to health facilities and educational facilities is measured by the distance between residence to the nearest facility. Nearly 100% of the households have proper access to health facilities due to the existence of a doctor's clinic in Tambak Lorok. On the other hand, household perceptions of the accessibility to junior high school are lower than to elementary or high school. Based on the Indonesian National Standard 03-1733-2004 (SNI), the allowed maximum radius for junior high school facility provision is 1000 m, whereas in reality, the distance betweenTambak Lorok to the nearest junior high school exceeds 2.5 km (National Standardization Agency of Indonesia 2004). Meanwhile, the location of elementary and high schools are in accordance to the standard, with the nearest elementary school located approximately 500 m away from residential areas, and the nearest senior high school is located 2 km away.

The stores and resources component consists of three subcomponents: savings ownership, home ownership, and land ownership. Only 31.74% of the households own savings, despite that savings would be beneficial in the even of urgent needs that require a large amount of money. Generally, households use savings to raise the floor of their homes that are affected by land subsidence. Households with no have savings will apply for a loan, and those with no access to loans are forced to let their homes hit by tidal flood and land subsidence. Savings is a part of capital

Table 4 Conclusion of Factor Analysis

Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Access to loans	Temperature rise	Health insurance	Poor households	Flooding
Experience of borrowing money	Rainfall	Savings	Head of households aged >64 years old	Female head of households

assets, which is a strategy to build a livelihood system in each household (Allison 2005). Savings ownership is closely related to household consumption. Consumption and savings are two perspectives of the same problem where lower consumption levels indicate a higher savings rate (Chen 2018). However, the low ownership of savings in Tambak Lorok is not directly caused by excessive household consumption. Households that do not possess savings generally have lowincome, which does not allow the household to save money.

5 Factor analysis assessment

Table 4 shows five factor groups derived from factor analysis. The first factor is Loans Accesibility, which is formed by two variables (access to loans and experience of borrowing money). Accessing loans is common in Tambak Lorok during a state of urgency. In fact, 67.37% of the households have been able to access loans. The average community members access loans to pay for house renovation. Some people applied for a loan from formal and non-formal institutions (Handayani and Kumalasari 2015). Access to loans is an adaptation capacity when the household economy is vulnerable. Therefore, it is a part of livelihood strategies that affects the vulnerability level of households.

The second factor covers the impact of climate change, which constitutes temperature rise and rainfall variables. Previous vulnerability index assessment shows that both variables are represented by high vulnerability indices. Of the total population, 86.83% has felt an increase in air temperatures, and 70.96% has felt a change in rainfall patterns. Climate change has affected human activities, especially in the primary sectors. The greatest impact of climate change is seen for jobs that depend on natural resources such as fishing, fish selling and related trades, which overall affects the community's income. Currently, climate change enhances existing levels of vulnerability, and to increase resilience, greater autonomy for local communities and also improved coordination by local government are required (Parraguez-Vergara et al. 2016).

The third factor represents access to capital assets, which consistutes health insurance ownership and savings ownership. From the perspective of capital assets, the sustainability of livelihood systems is determined by household ability to build capital assets (Allison 2005). However, low insurance ownership in Tambak Lorok causes difficulties when people are suddenly exposed to diseases that incur high medical costs, as opposed to if the community members have health insurance to cover their medical expenses. Similarly, despite that saving money is one of the livelihood strategies that will help solve funding problems, the vulnerability index

shows that not many households have savings. Such households are more prone to hardshipsin the event of sudden financial needs arise.

The fourth factor is vulnerable groups, which variables include poor households and household heads aged >64 years old. Vulnerable groups are individuals who face high risks due to their conditions, which affects productivity and the ability of households to deal with shocks and stresses. These two variables are dominant in Tambak Lorok. Based on the previous vulnerability assessment, the percentage of poor households reaches 33.8%. These poor households have difficulty accessing public services. In addition, 14.67% of the household heads are aged >64 years, which means that they are not of productive age. Households which head is of non-productive age have lower ability to cope with natural disasters, family economic crisis and other difficulties compared to those which head is of productive age.

The fifth factor include flooding and female household heads as variables. Although the two variables cannot be deduced into a single factor, they are related to other factors. Flooding is related to the second factor (impact of climate change), especially to the rainfall variable. The second variable, female household heads, is related to vulnerable groups. Female household heads are more vulnerable than the male counterparts because locally, women are more prone to gender inequality, especially if they are the sole breadwinner within a household. Moreover, they often fall in the rank of poverty as they, too, depend on others to cultivate their possessions (Rahmato 1991).

A majority of household heads work in the primary sector and indirectly depend on cash income as their source of livelihood. Factor analysis shows that among five factors, three consists of variables that suggest how much household capability is devoted to overcoming the lack of cash income (access to loan, experience of borrowing money, and savings swnership). When cash income is insufficient to support their life needs, community members are categorized as vulnerable urban poor.

The results of factor analysis showed an obvious contrast between the livelihood in Tambak Lorok that depends on cash income and the common livelihood in rural areas that mostly depends on natural resources (Meikle et al. 2001; Castells 2002). Among the five most influential factors, three of them indicate that the households in Tambak Lorok are more dependent on cash income. Borrowing money is the main solution to their economic problems, in the even that the households do not possess enough money or savings. The third (access to capital assets) and fourth (vulnerable groups) factors are related to the first factor. Access to loans and saving ownership are some ways to deal with economic problems without requiring the households to put aside their dependence on cash income. Commercialization and trade are the reasons why households depend on cash income. A low-income household is unable to reach the economic system, which causes the household to be marginalized, vulnerable, and categorized as poor.

6 Peculiarity of Tambak Lorok in terms of rural and urban livelihoods

Owing to the various characteristics of community livelihood in Tambak Lorok, livelihood cannot be classified entirely as either rural or urban. Several subcomponents of LVI showed the differences that characterizes rural livelihood, whereas others were unclear. The low education level of household heads and their occupations that mostly depend on natural resources indicate rural livelihood characteristics, whereas access to infrastructure and urban facilities indicate urban livelihood characteristics. We categorized the fundamental differences of urban and rural livelihood as well as mixed urban-rural in Tambak Lorok into four characteristics briefly presented in Table 5.

The characteristics of mixed urban-rural livelihoods are merely different compared to the features of both urban and rural livelihood. Table 5 provides an overview concerning those differences through LVI prespective by emphasizing the vulnerable components. For example, the sub component of Direct/Non Direct User presented high dependence on natural resources. However, their level of dependence on natural resources is not as large as that of rural communities, which are identical to agricultural activities. Although the tidal flood prohibits the community to gain ma-

Table 5 Comparison of characteristics among urban, rural, and urban-rural livelihood in Tambak Lorok

Characteristic Differences	Urban Livelihood	Rural Livelihood	Urban-Rural Livelihood in Tambak Lorok
Self Capabilities	The level of education is higher than that of the communities	A traditional community which members mostly lacking of education	Lack of education and resources
	Sources: Meikle et al. (2001); Mills et al. (2017)	*Sources:* Ellis (2000); Ellis and Freeman (2004); Redclift (2000)	*Sources:* LVI Score in Sub-Component of Education level of head of household (0.714)
Occupation types	Mostly work in non-primary sectors	Mainly work in primary sectors (Agriculture and food)	Community member mostly work in the primary sector (fisheries)
	Sources: Maxwell et al. (2000); Meikle et al. (2001); Castells (2002); de Haan (2017)	*Sources:* Rahmato (1991); Chambers and Conway (1992); Paavola (2008); Can et al. (2013)	*Sources:* LVI Score in Sub-Component of Direct/Non-direct users (0.512)
Sources of living	Less dependence on natural resources, high dependence on cash income	High dependence on natural resouces	High dependence on natural resources
	Sources: Meikle et al. (2001); Castells (2002)	*Sources:* Rahmato (1991); Paavola (2008); Can et al. (2013)	*Sources:* LVI Score in Sub-Component of Direct/Non-direct users (0.512)
Access to facilities	Easy access to infrastructures and urban services	Limited access to urban infrastructures and services	Easy access to infrastructures and urban facilities
	Sources: Ellis and Freeman (2004); Mills et al. (2017)	*Sources:* Redclift (2000); Castells (2002); Majale (2001); Paavola (2008)	*Sources:* LVI Score in Main Component of Claim and Access (0.221)

rine resources, they still can diversify their occupation to non-primary sector such as casual labours and freight workers. That is cannot be done suddenly by rural communities due to their occupations tends to be homogeneous (agricultural sectors). Another example was shown by the low LVI score on the component of Claim and Access, which means they can easily access urban services. Nevertheless, their livelihood still exhibits rural features, such as low educational levels and that most community members are primary sector workers.

The unique characteristics in Tambak Lorok illustrates a mix of urban and rural livelihoods, therefore the policy implications for improving livelihood capabilities covers those related to urban and rural areas. Policy implications to enhance livelihood capabilities in both urban and rural areas in general are equally intended to increase human capabilities (through the provision of educational facilities and training) as well as providing assistances (capital loans, infrastructure improvements, access to other facilities). Nevertheless, urban livelihood policies are mostly is emphasized on on understanding urban poverty and strategies to improve the poor (Meikle et al. 2001) while rural livelihood policies are closely linked to environmental protections and sustainable natural resources (Ellis 1999; Chambers and Conway 1992; Okojie 2014), which are rarely mentioned in the urban livelihood policies. The mixed livelihood characteristics in Tambak Lorok requires both of them, considering that the community members are categorized as urban poor and their jobs depend on the marine sector. In addition, infrastructure improvement in their neighborhood and building construction to reduce tidal flooding are urgently needed to reduce exposure to environmental damage.

7 Conclusion

This study has contributed to vulnerability assessment in a rural-urban neighborhood. Livelihood in rural perspectives is attributed to a great human dependence on natural resources, while there is also a lack of human capability and resources. An important issue is the inability of residents to take advantage of employment opportunities and diversify their income sources due to their low educational level. On the other hand, by virtue of its location in the urban area, community members in Tambak Lorok have easy access to infrastructure services. Due to close proximity to urban services, the vulnerability level is low for infrastructure services. However, households are not able to take advantage of these services and utilize them to improve their livelihoods.

Livelihood vulnerability in the urban-rural context in Tambak Lorok can be categorized as ‘slightly more resilient’ compared to rural livelihood vulnerability in general. Although the urban community members are less able to take advantage of their residential proximity to the city, they have greater opportunities to diversify their jobs and access to financial facilities compared to the rural community. However, their livelihood is also considered vulnerable given that the characteristics are equated with those of urban livelihood. Tambak Lorok community can be categorized as urban poor, meaning that they are certainly more vulnerable due to their low income and lack of capabilities compared to other urban communities with higher economic status.

Livelihood capability is a critical aspect in reducing vulnerability, including releasing them from poverty traps. An important way to enhanced livelihood capability is to enrich community knowledge and human resources so that they can solve their financial issues, such as providing access to loans, gaining a decent work, or finding new ways to earn more income. Furthermore, infrastructure improvement and building construction are very necessary to reduce their exposure to sea level rise and tidal floods.

Acknowledgements We are grateful for the support provided by Diponegoro University. We also thank the World Research Institute (WRI) and Initiative for Urban Climate Change and Environment (IUCCE) for providing data and information under the Urban Community Resilient Assessment (UCRA) Program in Semarang.

Funding The authors express acceptance of financial support for research and publication of this article to the Faculty of Engineering, Diponegoro University.

References

100 Resilient Cities (2016) Resilient Semarang-Moving together towards a resilient Semarang. www.100RCSemarang.org

Abidin HZ, Andreas H, Gumilar I, Sidiq TP, Fukuda Y (2013) Land subsidence in coastal city of Semarang (Indonesia): characteristics, impacts and causes. Geomat Nat Hazard Risk 4(3):226–240. https://doi.org/10.1080/19475705.2012.692336

Adger WN (2006) Vulnerability. Glob Environ Change 16(3):268–281. https://doi.org/10.1016/j.gloenvcha.2006.02.006

Akindola RB (2009) Towards a definition of poverty: poor people's perspectives and implications for poverty reduction. J Dev Soc 25(2):121–150. https://doi.org/10.1177/0169796X0902500201

Allison EH (2005) Potential applications of a 'sustainable livelihoods approach' to management and policy development for European inshore fisheries. In: Hart P, Johnson M (eds) Who Owns the Sea, Tjärnö: 24–27 June 2002, pp 25–43

Artha Nugraha (2017) Neigborhood upgrading action plan—Tanjung Mas vol 2

BAPPEDA Semarang City (2019) Regional action plans and adaptation to climate change Semarang City. Regional Planning and Development Agency of Semarang City, Semarang

Bartholomew DJ, Knott M, Moustaki I (2011) Latent variable models and factor analysis: a unified approach vol 904. John Wiley & Sons, Chichester

Bevacqua A, Yu D, Zhang Y (2018) Coastal vulnerability: evolving concepts in understanding vulnerable people and places. Environ Sci Policy 82:19–29. https://doi.org/10.1016/j.envsci.2018.01.006

Brenner T, Pflitsch G (2017) The raise of publications on sustainability—a case study in Germany. Rev Reg Res 37(2):189–225

Can ND, Tu VH, Hoanh CT (2013) Application of livelihood vulnerability index to assess risks from flood vulnerability and climate variability: a case study in the Mekong Delta of Vietnam. J Environ Sci Eng 2(8):476–486

Castells M (2002) Sustainable Cities: Structure and Agency. In: Evans, P. (ed) Livable Cities?: Urban Struggles for Livelihood and Sustainability. Berkeley; Los Angeles; London: University of California Press. pp ix–xi

Chambers R, Conway GR (1992) Sustainable rural livelihoods: practical concept for the 21st century. Institute of Development Studies 296:29

Chen X (2018) Why do migrant households consume so little? China Econ Rev 49(March):197–209. https://doi.org/10.1016/j.chieco.2017.11.005

Cinner JE (2011) Social-ecological traps in reef fisheries. Glob Environ Change 21(3):835–839. https://doi.org/10.1016/j.gloenvcha.2011.04.012

Downing TE, Patwardhan A, Klein RJ, Mukhala E, Stephen L, Winograd M, Ziervogel G (2005) Assessing vulnerability for climate adaptation. In: Lim B, Spanger-Siegfried E (eds) Adaptation Policy Frameworks for Climate Change: Developing Strategies, Policies and Measures. Cambridge University Press, Cambridge, pp. 67–89

Ellis F (1999) Rural livelihood diversity in developing countries: evidence and policy implications (Natural Resource Perspectives Vol. 40, No. 1, pp. 1-10). Overseas Development Institute, London http://hdl.handle.net/10535/4486
Ellis F (2000) The determinants of rural livelihood diversification in developing countries. J Appl Econ Sci 51(2):289–302
Ellis F, Freeman HA (2004) Rural livelihoods and poverty reduction strategies in four African countries. J Dev Studs 40(4):1–30
Ferrol-Schulte D, Wolff M, Ferse S, Glaser M (2013) Sustainable livelihoods approach in tropical coastal and marine social-ecological systems: a review. Mar Policy 42:253–258. https://doi.org/10.1016/j.marpol.2013.03.007
Füssel HM (2007) Vulnerability: a generally applicable conceptual framework for climate change research. Glob Environ Change 17(2):155–167. https://doi.org/10.1016/j.gloenvcha.2006.05.002
de Haan L (2017) Rural and urban livelihoods, social exclusion and social protection in sub-Saharan Africa. Geogr Tidsskr 117(2):130–141. https://doi.org/10.1080/00167223.2017.1343674
de Haan A, Drinkwater M, Rakodi C, Westley K (2002) Methods for understanding urban poverty and livelihoods. UK Department for International Development's Infrastructure and Urban Development Department. http://www.mumbaidp24seven.in/reference/deHaanetal_urb_pov2.pdf
Hahn MB, Riederer AM, Foster SO (2009) The livelihood vulnerability index: a pragmatic approach to assessing risks from climate variability and change—A case study in Mozambique. Glob Environ Change 19(1):74–88. https://doi.org/10.1016/j.gloenvcha.2008.11.002
Hair JF Jr, Black WC, Babin BJ, Anderson RE (2010) Multivariate data analysis, 7th edn. Pearson Education, Harlow
Handayani W, Kumalasari NR (2015) Migration as future adaptive capacity: the case of Java—Indonesia. In: Hillmann F, Pahl M, Rafflenbeul B, Sterly H (eds) Environmental change, adaptation and migration. Palgrave Macmillan, London, pp 117–138
Handayani W, Rudiarto I, Setyono JS, Chigbu UE, Sukmawati AMA (2017) Vulnerability assessment: a comparison of three different city sizes in the coastal area of Central Java, Indonesia. Adv Clim Change Res 8(4):286–296
Lohmann H (2016) Comparing vulnerability and adaptive capacity to climate change in individuals of coastal Dominican Republic. Ocean Coast Manag 132:111–119. https://doi.org/10.1016/j.ocecoaman.2016.08.009
Majale M (2001) Towards pro-poor regulatory guidelines for urban upgrading. In: A review of papers presented at the International Workshop on Regulatory Guidelines for Urban Upgrading held at Bourton-on-Dunsmore, pp 17–18
Maxwell D, Levin C, Armar-Klemesu M, Ruel M, Morris S (2000) Urban livelihoods and food and nutrition security in Greater Accra, Ghana. IFPRI, Washington, DC
Meikle S, Ramasut T, Walker J (2001) Sustainable Urban Livelihoods: Concepts and Implications for Policy 333(112). https://www.ucl.ac.uk/bartlett/development/sites/bartlett/files/migrated-files/wp112_0.pdf
Mills DJ, Tilley A, Pereira M, Hellebrandt D, Fernandes AP, Cohen PJ (2017) Livelihood diversity and dynamism in Timor-Leste; insights for coastal resource governance and livelihood development. Mar Policy 82:206–215
Ministry of Public Work (2017) Neigbourhood Upgrading Shelter Project (NUSP). Ministry of Public Work, Semarang
Mulyana W, Setiono I, Selzer A K, Zhang S, Dodman D, Schensul D (2013) UNFPA Urbanization and Emerging Population Issues: Urbanisation, Demographics and Adaptation to Climate Change in Semarang, Indonesia (September 2013). http://www.iied.org/pubs/display.php?o=10632IIED
National Standardization Agency of Indonesia (2004) SNI 03-1733-2004 about housing planning procedures in Urban areas (Tata Cara Perencanaan Lingkungan Perumahan di Perkotaan)
Okojie LO (2014) Cement production and sustainable rural farming livelihood in Nigeria: striking a sensible balance through environmental legislation and enforcement. Eur J Sustain Dev 3(3):251–251
Organization of American States (2015) Handbook on cities and livelihood (part I). Department of Sustainable Development, Washington DC:
Paavola J (2008) Livelihoods, vulnerability and adaptation to climate change in Morogoro, Tanzania. Environ Sci Policy 11(7):642–654. https://doi.org/10.1016/j.envsci.2008.06.002
Parraguez-Vergara E, Barton JR, Raposo-Quintana G (2016) Impacts of climate change in the Andean Foothills of Chile: economic and cultural vulnerability of indigenous Mapuche livelihoods. J Dev Soc 32(4):454–483. https://doi.org/10.1177/0169796X16667874

Prevention Web (2015) Vulnerability. https://www.preventionweb.net/risk/vulnerability. Accessed 15 Sept 2015

Purwanto E, Setioko B, Olivia D (2017) Faktor-Faktor Pengaruh Kinerja Permukiman Sebagai Antisipasi Perwujudan Kampung Wisata Bahari. Tataloka 19(1):1. https://doi.org/10.14710/tataloka.19.1.1-14

Rahmato D (1991) Famine and survival strategies: a case study from Northeast Ethiopia. In Food and Famine Monograph Series No. 1. Uddevalla: Bohuslaningens Boktyckeri AB

Redclift MR (ed) (2000) Sustainability: life chances and livelihoods. London and New York: Routledge

Rudiarto I, Handayani W, Wijaya HB, Insani TD (2019) Rural Livelihood Resilience: An Assessment of Social, Economic, Environment, and Physical Dimensions/ MATEC Web Conference. https://doi.org/10.1051/matecconf/201928001002

Salafsky N, Wollenberg E (2000) Linking livelihoods and conservation: a conceptual framework and scale for assessing the integration of human needs and biodiversity. World Dev 28(8):1421–1438

Sari IKW, Hadi SP (2018) Climate change anticipation on supporting capacity of fishing environment in the coastal area of Tanjungmas Semarang city. In: International of Conference on Energy, Environmental, and Information System Semarang. vol 09016, pp 1–7 https://doi.org/10.1051/e3sconf/20183109016

Schütte S (2005) Emerging trends in Urban livelihoods. Retrieved from Afghanistan Research and Evaluation Unit website: http://www.afghandata.org:8080/xmlui/handle/azu/15263

Scoones I (2009) Livelihoods perspectives and rural development. J Peasant Stud 36(1):171–196. https://doi.org/10.1080/03066150902820503

Sejati AW, Buchori I, Rudiarto I (2019) The spatio-temporal trends of urban growth and surface urban heat islands over two decades in the Semarang Metropolitan Region. Sustain Cities Soc 46:101432

Shah KU, Dulal HB, Johnson C, Baptiste A (2013) Understanding livelihood vulnerability to climate change: applying the livelihood vulnerability index in Trinidad and Tobago. Geoforum 47:125–137. https://doi.org/10.1016/j.geoforum.2013.04.004

Turner BL, Kasperson RE, Matson PA, McCarthy JJ, Corell RW, Christensen L, Polsky C (2003) A framework for vulnerability analysis in sustainability science. Proc Natl Acad Sci 100(14):8074–8079

Yong AG, Pearce S (2013) A beginner's guide to factor analysis: focusing on exploratory factor analysis. TQMP 9(1):79–94. https://doi.org/10.1057/tqmp.09.2.p079