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Towards a more sustainable and resilient future: Applying the Regional Circulating and Ecological Sphere (R-CES) concept to Udon Thani City Region, Thailand

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ABSTRACT

A city region is a unit comprising an urban core and surrounding peri-urban and, occasionally, rural areas. The Regional Circulating and Ecological Sphere (R-CES) proposed by the Japanese government is a guiding approach for policymaking that prioritises the harmonised flow of resources between urban and rural areas, low-carbon society, circular economy, and self-sufficiency in order to achieve sustainability and resilience. This paper aims to examine whether the R-CES concept is applicable for the Udon Thani city region in northeastern Thailand, which is facing challenges arising from urban growth and disaster risks such as water shortages, drought, and flooding. The objectives of the research are therefore to understand the urban-rural linkages in Udon Thani in the dimensions of food and water security and personal mobility patterns, as well as the residents' awareness of urban-rural interdependencies and willingness for urban-rural partnerships according to the R-CES concept. The research results demonstrate that there are resource dependencies between the urban, peri-urban and rural areas, which is recognized by the surveyed residents, and that R-CES is a feasible framework for guiding localised actions towards increased sustainability and disaster risk resilience in Udon Thani.

1. Introduction

Rapid urbanisation and population growth is a transformative phenomenon that increases the demands for available resources and creates a new configuration of space. The changes brought about by urbanisation are not limited to the confines of the city itself, because of the interactions between the urban, peri-urban, and rural areas within the same region. Higher demand for resources in the urban core can negatively affect the surrounding areas. Rapid urbanisation also has the risk of exacerbating not only socio-economic inequality within the urban core (if the developments fail to take into account the urban poor) but also the economic and infrastructural inequality between the urban core and the rural areas [1], which negatively affects climate and disaster risk resilience of the region. It is therefore important for rapid urbanisation to be accompanied by partnerships or collaborations between the urban, peri-urban and rural areas in order to drive an integrated approach to development. The shift from sectoral to territorial approaches to development planning has led to the emergence of the concept of the "city-region", which brings together the urban, peri-urban and, occasionally, rural area, under one denomination, thus creating a new scale for which development policies could be created and implemented [2]. A city region comprises a metropolitan area or an urban zone and the surrounding areas which could function as a single socio-economic unit through linkages of shared resources such as business districts, markets, and transport networks [3].

Despite the rising popularity of the city region approach for development planning, it is still not as widely used as the more traditional sectoral approaches. This is, in part, due to how development strategies for city regions are more complex and require more expansive research, as they require not only different policies but also governance structures that allow horizontal and vertical coordination of numerous institutional public and private actors [4]. Another reason is that the definition of a city-region as a unit of governance is contested and different authorities may not have an agreed upon boundary of a city region. In the context of Thailand, there is limited research that has been done to support or examine the applicability of a city region approach to development. This research therefore aims to produce an analysis that can help support the application of a framework at the city region scale, the Regional Circulating and Ecological Sphere (R-CES) which has not been applied in Thailand before.

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The objective of this research is to examine the following questions: 1.) What are the urban-rural linkages in Udon Thani in the dimensions of food and water security and human flows, and 2.) what is the level of the residents' awareness of urban-rural interdependencies and would they be likely to support urban-rural partnerships for sustainable development and increasing resilience. These objectives allow the research to examine the applicability of the Regional Circulating and Ecological Sphere (R-CES) concept for promoting sustainable development in Udon Thani, as R-CES is a framework that emphasises the importance of managing resource flows between different areas, as well as cross-jurisdiction political and bottom-up collaboration. Regional Circulating and Ecological Sphere (R-CES) is a concept that was introduced in 2018 in the Fifth Basic Environmental Plan of Japan as a guiding concept for development policies [4]. R-CES brings together existing concepts in sustainable development, such as circularity, decarbonization, ecosystem-based solutions, and fostering urban-rural linkages, in order to create a paradigm shift for a self-reliant, resilient and decentralised society. However, it should be noted that a key challenge that limits the understanding of applications of R-CES in different contexts is the lack of clear guidelines on how the concept can be applied to different localities [5].

This paper presents the social network analysis and household surveys conducted for the object of providing insight into the interdependencies and linkages between the urban, *peri*-urban and rural areas in the socio-economic, resources management and collective resilience dimensions. This information can help support sustainable resource management policymaking and allow the unique strengths of urban-peri urban-rural linkages in the Udon Thani City Region to be utilised according to the R-CES approach. The results of this research also complement and offer the demand perspective to the supply-side environmental and geographical factors that affect Udon Thani city region's potential for sustainable development. Section 2 of this paper explains the background, conceptual framework and methodology used for the study; Section 3 shows the results of the social network analysis, household survey, and stakeholder consultation; Section 4 discusses the implications of the results with regards to the R-CES framework, and Section 5 provides a conclusion to this research.

2. Materials and methods

2.1. Conceptual framework

This research utilises the Regional Circular and Ecological Sphere (R-CES) framework, which was first proposed in the Fifth Basic Environmental Plan of Japan as a guiding concept for environmental policies, in order to support the achievement of Sustainable Development Goals (SDGs) in Japan as well as in other countries. The goal of R-CES is to create "a self-reliant and decentralised society where different resources are circulated within each region, leading to symbiosis and exchange with neighbouring regions according to the unique characteristics of each region […] to re-discover regional resources and make optimum use of them in a sustainable manner" [6]. The concept suggests that self-reliance is key to sustainable resource management and to climate risk resilience. R-CES promotes practices such as recycling and minimising waste, which is similar to practices put forth by the circular economy framework [7]. One characteristic that distinguishes R-CES from conventional approaches to circularity is that R-CES offers a holistic view of urban-rural linkages, and takes into account not only the material flows of goods, resources and energy, but also non-material flows such as the flow of people and information. The R-CES concept emphasises the need for local production of renewable energy and de-carbonization, while also advocating for the exploration of innovative solutions to environmental problems through partnerships of stakeholders and partnerships between different regions, especially between urban and rural areas. R-CES therefore can be understood as a comprehensive concept that aims to apply principles of circularity on a regional scale, in a way that is collaborative and valorizes local strengths and resources, in order to achieve resilience.

R-CES is a concept that could be particularly useful for policy making because of how it was designed to enable tangible policies based on its principles, such as strategic collaboration with neighbouring jurisdictions in a way that allows all parties to benefit from each other's strengths. Ortiz-Moya et al. [10] explores the four different approaches covered by the CES umbrella: rural–urban linkages, ecosystem-based solutions, decarbonisation, and resource circulation, concluding that "CES fosters holistic and integrated responses to sustainable transitions in which symbioses between these four approaches appear organically." However, the authors also raised that further research is required to examine how the approach can be applied at the appropriate scale and how to better understand and balance the trade-offs between achieving a low-carbon and circular society and the potential negative impacts these can have on nature. R-CES has been used as a guiding principle for comprehensive plans in Japanese prefectures such as Nagano [8]. The concept has also been applied to research in regions outside of Japan, such as Nagpur, a large, rapidly growing city in India, where it was found that R-CES was useful in providing a guiding framework for the analysis of resource flows between urban and rural areas within the context of sustainable urbanisation [9]. In comparison to Nagpur city region, this research provides a case study on the application of R-CES on a study area that is significantly smaller in size and population.

This research focuses on urban-rural linkages and resource flows components of the R-CES approach, which emphasises fostering partnerships between urban, peri-urban, and rural areas through strategic resource circulation and integrated low carbon development pathways. The R-CES approach emphasises how the urban, peri-urban and rural areas are interconnected through the flows of food, water, energy, remittances, raw materials, finished products, labour, waste, and pollution. Ecosystem services in rural and peri-urban areas are viable for protecting people and properties in urban areas. In turn, economic activities in urban centres can create economic opportunities and improve the livelihood of people living in rural and peri-urban areas. The interconnections between urban, peri-urban and rural areas means that interconnectedness means that vulnerability to hazards among urban, peri-urban, and rural areas are also intrinsically linked. The R-CES approach encourages comprehensive disaster risk resilience by encouraging the collaboration between urban and rural areas, and for policies to take into account these relationships between these areas in order to optimise plans for disaster preparedness and solutions to existing environmental problems.

The research framework as well as the indicators formulated by the researchers based on R-CES are presented below in Fig. 1. The research aims to establish a deeper understanding of the natural resource flows and usage, resource dependency and water and food market linkages within the study area, which is within the Udon Thani city region. The water and food dimensions were selected as they are resources that are essential not only for day to day life but also for urban growth and disaster preparedness. Water, in particular, is important to Udon Thani as a region that experiences frequent flooding and drought. A key criterion for the study area was that it should be one containing both urban and rural areas, and could therefore demonstrate the resource flows between the different areas as per the scope of R-CES.

The selected study area for this research comprises connected urban, peri-urban and rural areas. The definition of what an urban or a rural area is can depend on criteria such as the population size, population density, and availability of services, such as mass-rapid transit systems. However, it should be noted that the criteria used to make this urban-rural categorization can vary greatly depending on the specific area in question as well as the national or regional context in which they are situated [11]. In addition to the urban-rural binary, there is also the peri-urban area which exhibits both urban and rural characteristics. Peri-urban areas can vary significantly by having different concentrations of various land uses, such as high- and middle-income residential developments, industrial estates, informal settlements, agriculture. In Thailand, peri-urban areas often consist of small agricultural lands, small-scale factories, medium-scale (and even large-scale) industrial

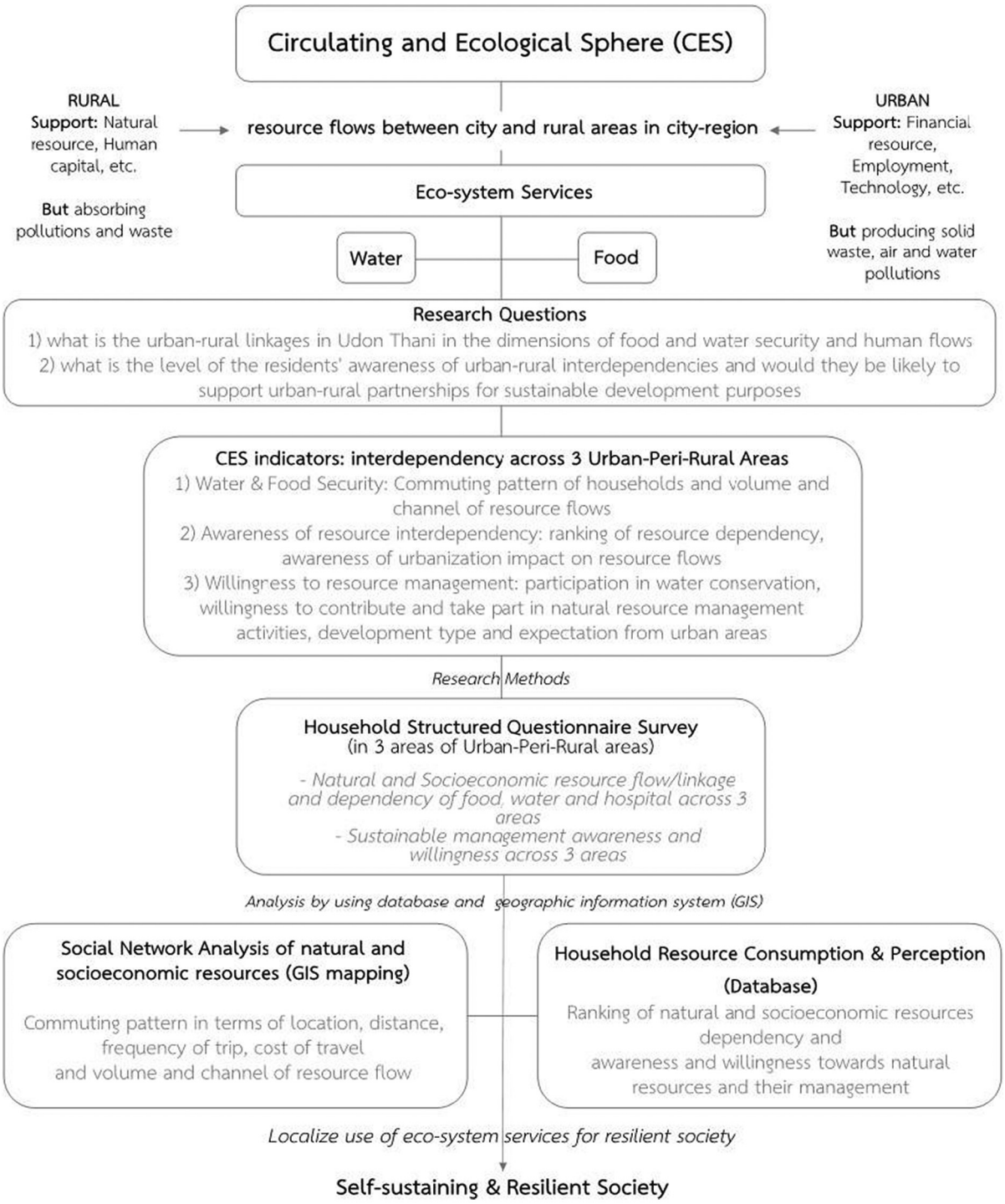

Fig. 1. Research framework.

estates, and suburban upper-middle-class residential developments co-existing side by side.

This research is interested in examining the resource flows and interdependencies between the urban, peri-urban and rural areas, as well as to examine the awareness and willingness of surveyed residents of in the study area with regards to sustainable resource management, which provides insight into the opportunities for community participation in sustainable development as per the R-CES framework. Moreover, the Social Network Analysis provides spatial information that can be used in guiding sustainable development policies or programs.

2.2. The case study area: Udon Thani city region

Udon Thani is the 11th biggest province in Thailand that is located in the northeast of the country, not far from the Laotian border. The province comprises mostly plateaus, with some low lands, mountains, and undulating topography. Udon Thani is divided into 20 administrative districts called *amphoe*, which is in turn made up of smaller units of 67 sub-district municipalities, 1 city municipality, 3 municipalities and 109 subdistrict administrative organisations. As of 2014, the population of Udon Thani is 1,570,300 persons, and a third of the population are residents of the

municipal and urban areas. The GDP of the province has almost doubled in the past 10 years, and the local economy is dependent largely on the service sector (mainly in commerce, transport, retail), industrial, and agricultural sectors [12].

The study area of this research is the Udon Thani city region. The city region can be understood as the combination of an urban core and the connected peri-urban and occasionally rural hinterland areas that share functional ties as well as services and resources [2,3]. The Udon Thani city region therefore comprises Udon Thani city municipality (the urban centre of the province) and the surrounding peri-urban and rural areas. As an area that is experiencing growth as well as difficulties arising from resource management, the Udon Thani city region was chosen as a study area for the application of the R-CES concept as it is one of the examples of a geography where there is a need for an approach of sustainable development that takes into account the interrelations between the urban, peri-urban and rural areas, and a study area where ecosystem services, especially in the dimensions of food and water, can play a role in furthering resilience. Here, resilience is understood as "the measurable ability of any urban system, with its inhabitants, to maintain continuity through all shocks and stresses, while positively adapting and transforming toward sustainability" [13].

The Udon Thani city region is experiencing urban expansion, in part due to the growth of its industrial and service sectors. This urban growth can exacerbate environmental risks that the city region experiences. Udon Thani province has experienced severe flooding due to heavy rainfall in 2001, 2002, 2009, and 2011 [14]. The province also experienced many long periods of drought. As a consequence of climate change, it is likely that Udon Thani will experience longer and dryer summers, heavier localised rain, and more volatility between too much and not enough rainfall. The increase in urban built structures could worsen the impact of flooding by blocking waterways and by increasing risk exposure, while the increase in facilities and residents in urban areas will increase the demand for potable water, which can have adverse impact on water resource management. At present, both the urban and most of the rural areas in Udon Thani receive potable water that comes from the Huai Luang water reservoir. In years with low rainfall, there is less water available in the reservoir, which directly affects the available water supply. In such instances, the water supply to the urban area is prioritised due to the area's high economic value, which can cause tension between the urban core and the agricultural areas where water is also needed for agricultural purposes.

2.3. Research methods

2.3.1. Household survey

A household survey was conducted to shed light on the structures, behaviour and perceptions of households in the study area. The survey focuses on understanding the respondents' household structure, water usage characteristics, relationship to food and the markets, perception of natural resource management, commuting pattern, and migration and remittance behaviour. This information helps establish an analysis of the social networks, mobility patterns, and the relationship and dependency between the urban, peri-urban and rural areas.

The survey was conducted in settlements along the corridor from the Udon Thani Provincial Hall to Huai Luang Reservoir (i.e., the ecological corridor of the Huay Luang reservoir), covering a total of fourteen subdistricts (*Tambon*). For the purpose of the research, the study area was divided into urban, peri-urban and rural zones based on their distance from the Udon Thani Provincial Hall in the city centre. The urban zone is the area within 0 to 5 km, the urban area is the area between 5 and 10 km, and the rural zone is 10 to 25 km. This categorization was made based on the land use map provided by the Land Development Department of Udon Thani. The urban area comprises important commercial facilities as well as a high concentration of utilities and built infrastructure, including housing, government buildings, and the economic centre of Udon Thani province. The peri-urban area has built structures such as housing, warehouses for agricultural products and factories along the main roads, and dispersed agricultural land. The rural area has a small number of built structures, but contains important resources such as water and forestry sources, and is the main site of food production that provides food security for the *peri*-urban and urban areas.

The researchers identified the different settlements in each zone and conducted field visits to conduct the household survey in person. Two sets of questionnaires were developed and used: one for settlements in the urban area, and the other for settlements in the peri urban and rural areas. Different questionnaires were developed because the context and lifestyles of residents differ according to the area that they live in. For example, there are no agricultural activities happening in the urban area, so instead of questions relating to food production, urban residents are asked about food market linkages and their consumption patterns. Meanwhile, the questionnaire for the rural area residents contains questions about what type of crops they are cultivating. It was decided that the same questionnaire was to be used in both the *peri* urban and rural areas because despite its urban characteristics, the peri urban areas share more characteristics with rural areas, such as extensive agricultural areas. Simple random sampling was used to choose respondents, and the research staff visited them door to door due to constraints of the COVID-19 pandemic. The researchers also consulted with local government authorities and local academics in order to identify areas along the ecological corridor of the study area that are easily accessible. The assistants who delivered the surveys were also informed about the context of the research and the R-CES framework, so they were able to provide contextual information to the respondents. The questionnaires were completed by a total of 571 households: 150 households in the urban area, 100 households in the peri-urban area, and 321 households in the rural area. The sample size in the rural area is larger than that of other areas in order to represent the viewpoints of different communities that are spread out over a larger geographical area.The surveys were anonymous and completed on a voluntary basis. The responses from the household surveys enabled the analysis of natural and socioeconomic resources usage and dependency, and the level of awareness and willingness towards natural resource and management of the respondents. The survey results were also used for the social network analysis and the GIS mapping of the respondents' commuting pattern in terms of location, distance, frequency of trip, cost of travel, volume and channel of resource flow (Fig. 2, Table 1).

2.3.2. Stakeholder consultation workshop

After the household survey was conducted and analysed, a stakeholder consultation workshop was held on 18 June 2021. The purpose of the workshop was to present the research findings, to establish deeper understanding about the Udon Thani City Region from the perspective of different groups, which could allow for a more comprehensive design of policies and plans based on the R-CES framework, as well as to collect feedback on the participants' ideas on how urban-rural sustainability can be achieved. The workshop was conducted as an online virtual meeting due to restrictions brought about by the COVID-19 pandemic. The online format of the workshop is a limitation as interlocutors may be unfamiliar with virtual meetings and therefore were less able or willing to contribute fully to the conversation.

After being introduced to the R-CES concept, the stakeholders are asked to share their thoughts on 1.) what issues the CES approach can alleviate, 2.) whether the CES approach is important in solving the issues of local interconnection and 3.) whether there are policies or partnerships that would support CES in tackling urban, peri-urban and rural interconnectivity, and 4.) which organization or agency should be the driver for CES for the resilience of both urban and non-urban areas in a way that is consistent with local needs.

The participating stakeholders include local government officials, business owners, civil society organisations (CSOs), non-governmental organisations (NGOs), academia, media personnel, city planners, and other public representatives, including village health volunteers (VHV). In Thailand, Village Health Volunteers are a core component of the public health system. They are trained volunteers who are able to perform basic

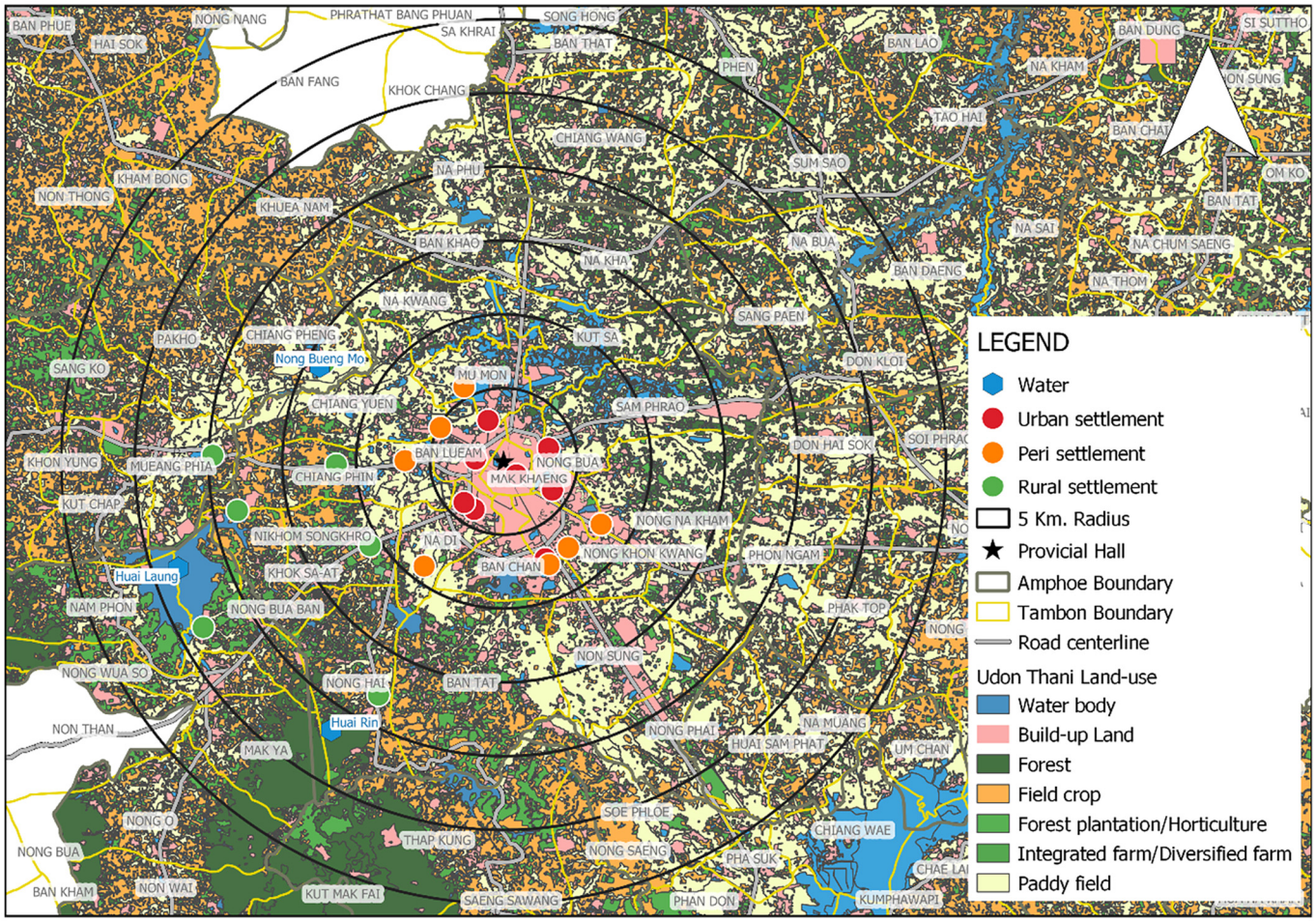

Fig. 2. A map showing the typology of the study area and the settlements of the survey respondents.

health checks as well as disseminate public health information, often going door-to-door to serve the community [14]. Community leaders, and research collaborators who assisted with the household survey also participated in the stakeholder consultation workshop. The participants were selected based on their occupations, so that they would represent key actors who are usually involved with regional development policymaking in Thailand.

Participants from Udon Thani municipality, Udon Thani Provincial office and various community-based organisations agreed that there are opportunities for making successful Urban-Rural partnership, and proposed

Table 1
Number of respondents for each settlement type (urban, peri-urban, rural).

Settlement type	Tambon	Amphoe	Samples (respondents)
Urban	Mak Khaeng	Muang Udon Thani	128
	Nong Bua	Muang Udon Thani	5
	Ban Lueam	Muang Udon Thani	3
	Others (Mu Mon, Na Di, Ban Chan, Sam Phrao, Chiang Phin)	Muang Udon Thani	14
Total			150
Peri-Urban	Nong Bua	Muang Udon Thani	22
	Mu Mon	Muang Udon Thani	19
	Ban Lueam	Muang Udon Thani	19
	Nong Khon Kwang	Muang Udon Thani	8
	Na Di	Muang Udon Thani	11
	Chiang Pin	Muang Udon Thani	11
	Ban Chan	Muang Udon Thani	10
Total			100
Rural	Chiang Pin	Muang Udon Thani	50
	Nikhom Songkro	Muang Udon Thani	60
	Nong Hai	Muang Udon Thani	52
	Kok Sa-art	Muang Udon Thani	14
	Chiang Pheng	Kut Chap	46
	Mueang Phia	Kut Chap	49
	Nong Bua Ban	Nong Wua So	50
Total			321
Total respondents			571

organising steering teams. It was proposed that the Udon Thani Provincial authority should function as the central coordinating body that engages all the stakeholders (which includes civil society and universities) and local communities to promote the Urban-Rural partnership following the Regional-CES framework and to work cross-boundary in Udon Thani Province and surrounding provinces (Table 2).

3. Results

3.1. Social network of resource flows between the urban, peri-urban and rural areas

Data from the household survey on the respondents' mobility and consumption habits and frequencies were analysed to provide insight into the flows of resources between the urban, peri-urban and rural study areas. GIS was used to visualize and map the location, frequency of use and distance from the users of various resources (Fig. 4). In the urban and peri-urban areas, the main source of potable water is from the Huai Luang reservoir, which is located in the rural area and is managed by the Provincial Waterworks Authority. The water is used for household and commercial consumption in the urban and peri-urban areas, as well as for some agricultural purposes in the peri-urban area. The household survey examines the distance from the residences to the water source, the consumption volume and the monthly costs of water according to the water metre shows that it takes longer for water to arrive to households in the urban and peri-urban areas because they are dependent on a water source that is located in the rural area. However, the household surveys revealed that residents in the urban area use less water than residents in the peri-urban and rural areas, because they do not need water for agricultural purposes. Meanwhile, residents of the rural area do not usually rely on the Huai Luang reservoir for water. Some rural settlements have their water reservoir or community water supply system for household usage. Most of the households in the rural areas own agricultural land and rely on water ponds and groundwater for their agricultural activities.

In the urban area, the sources for food are the central and local markets, supermarkets, and convenience stores. Key centres for the distribution of goods are the Mueang Thong Charoensri Market and Thai ESarn market, which are large markets offering a wide variety of consumer goods as well as agricultural products. Many respondents go to such markets on a monthly basis to purchase rice and other produce. Local markets, on the other hand, are smaller and are more likely to be frequented on a weekly basis by urban and peri-urban residents to purchase grains, vegetables, fruits, and prepared food. These are wet markets or street markets, such as the Nong Bua Market and the Udon Ngon Share Market. The supermarkets and convenience stores in the area are mostly chain stores. In the peri-urban area there are some food production activities, such as small-scale vegetable farms whose produce are sold through a middleman or at a local farmers' market. The survey revealed that farmers from rural areas depended on the businesses, warehouses, and transport hubs in the urban area to sell and transport their agricultural produce, such as rice, fruits, and vegetables, to various markets and products, such as sugarcane and cassava, to food-processing factories domestically and overseas. For this reason, as the peri-urban area is more urban than it is rural, the survey respondents did not have much agricultural land (1–5 *rai,* a Thai unit of measurement that is equivalent to 1600 square metres). Most of the produce cultivated in this area are garden vegetables for personal consumption.

With regards to healthcare, the survey examined the frequency of use of healthcare facilities per month, the distance from the residence to the hospital, as well as the costs of travelling to the hospital each time. It was found that both hospitals in the urban centre and hospitals in the suburban areas are frequented by residents of urban, peri-urban and rural areas, and that the urban residents have the shortest distance and cost of travel from hospitals and other medical facilities, as they are often located in urban areas as well.

Table 3 presents the findings from the survey which show the number of surveyed households from the urban and peri-urban areas, who reported their usage or frequentation of various sites. Each respondent, who represented one household, were asked to indicate from where they purchased different types of produce in the past 3 months. Some respondents provided multiple answers for each product category. The table shows that local markets are the main place from which urban residents acquire their food, and that the majority of respondents (110 out of a total of 150 households) responded that they purchase vegetables from the local markets. The table also shows that most of the frequented establishments for food are located in the urban area, while the markets and vendors in the peri-urban are frequented by very few respondents.

Table 4 shows details about the hospitals that are frequented by residents from the urban and peri-urban settlements. The majority of respondents reported that they frequent the Udon Thani hospital, which is the largest medical facility in the province.

In the rural areas, potable water used in households are from the Huai Luang reservoir, Huai Rin Reservoir, and Nong Bueng Mor, which is a small reservoir located in the rural area that is used for a community water supply. With regards to food, the rural area is a net producer of food for domestic and international consumption, which is sold through middlemen or at markets in the urban area. Therefore, only a small number of surveyed households responded that they purchase food from the markets and other entities in the rural area, as shown in Table 5. The food dependency of the residents from rural areas is therefore different from that of urban and peri-urban residents: they depend on the markets not for consumption but for selling their produce. Usually, crops are harvested once or twice per year, and the average size of agricultural land per household is 10 rai, with 1 rai of water reserve in their own property. For rice farming, at least 20 rai of land is used, with 1 rai of water reserved. Most of the crops produced are rice, vegetables, and tapioca. Most rice mills are located in the suburban area and most vegetables are sold in markets in the urban area such as the Mueang Thong Charoensri Market and Chiang Pheng

Table 2
The stakeholder workshop participants on 18 June 2021.

Participants	Organisations
Municipal Clerk (Acting Mayor)	Udon Thani Municipality
Deputy Municipal Clerk	Udon Thani Municipality
Director, Division of Public Works	Udon Thani Municipality
Director, Division of Public Health and Environment	Udon Thani Municipality
Director, Strategy and Planning Division/Budgeting Analysis Subdivision	Udon Thani Municipality
Director, Division of Social Welfare	Udon Thani Municipality
Director, Local Education Development Division	Udon Thani Municipality
Chief of the Local Development Plan Monitoring and Evaluation Subdivision	Udon Thani Municipality
Director of Administration Section	Udon Thani Province
General Administration Officer, Practitioner Level. Mu Mon Subdistrict Administrative Organization	Mu Mon Subdistrict Administrative Organization
President, Khlong Charoen 2 Community	Khlong Charoen 2 Community
President, Ban Huay 2 Community	Ban Huay 2 Community
President, Wiang Phing Community	Wiang Phing Community
President, Thung sawang Tawan Tok 2 Community	Thung sawang Tawan Tok 2 Community
Plan and Policy Analyst, Udonthani Provincial Agriculture and Cooperatives office Dothan	Udonthani Provincial Agriculture and Cooperatives office
Co-Founder of Ma:D Esan, Community Based Organisations and National Expert for the GIZ/SMMR Project in Thailand	German Cooperation (GIZ) and Sustainable Design of Urban mobility in Medium-Sized Metropolitan Regions (SMMR)
IGES Team	Institute for Global Environmental Strategies (IGES)
Thammasat University Research unit in Urban Futures and Policy	Thammasat University

Table 3
Location of food market and agricultural products in urban and peri-urban areas.

Settlement	Number of surveyed households	Product	Number of households that purchase the product from each site				
			Central market	Local market	Supermarkets	Street vendors	PDS (Public distribution system)
Urban	150	Food grains	30	48	26	9	20
		Vegetables	35	110	19	10	21
		Fruits	29	75	25	48	28
		Processed food	25	39	24	8	27

Settlement	Number of surveyed households	Product	Number of households that purchase the product from each site			
			Central market	Local market	Street vendors	Industrial factory
Peri-urban	100	Vegetables and rice	2	3	1	
		Vegetables	7		5	

Table 4
Location of infrastructure (hospital and health care center) in the urban and peri-urban areas.

Settlement	Number of surveyed households	Hospital code	Hospital name	Location (subdistrict)	Number of households that use the hospital
Urban	150	1	Udon Thani Hospital	Mak Khaeng	76
		2	Udon Thani Municipality Hospital	Mak Khaeng	29
		3	Municipality 8 Health Center	Mak Khaeng	9
		4	Prachak Silapakhom Military Camp Hospital	Mak Khaeng	7
		5	Bangkok Hospital	Mak Khaeng	9
		6	Aek Udon International Hospital	Mak Khaeng	11
		8	Kao Chan Public Health service center	Mak Khaeng	8
		13	Phen Hospital	Phen	1

Settlement	Number of surveyed households	Hospital code	Hospital name	Location (subdistrict)	Number of respondents who use the hospital
Peri-urban	100	1	Udon Thani Hospital	Mak Khaeng	85
		2	Udon Thani Municipality Hospital	Mak Khaeng	3
		7	North Eastern Wattana Hospital	Mak Khaeng	4
		9	Nong Bua Health Center	Mak Khaeng	3
		10	Mu Mon Health Center	Mu Mon	3
		11	Nadi Community health centre	Nadi	2

Table 5
Location of food market and agricultural products in rural settlement.

Settlement	Number of households	Purpose of visit	Number of household visited/Density of household visited			
			Central market	Local market	Street vendor	Industrial factory
Rural	321	For consumption/Non-food products	6	4		22
		For consumption, For export		12	7	38
		For export, Horticulture, Non-food products	6	2	2	7
		For consumption		3		

Municipality Market, which means that most farmers are highly dependent on facilities outside of the rural areas. Tapioca, on the other hand, is sold to processing facilities that are located in rural areas. Respondents in the rural area frequent hospitals in the urban area as well as hospitals that are near their homes (Fig. 5, Table 6).

Table 7 shows the frequency, distance and cost of displacements for food and access to health facilities. The range of volume columns refers to the volume of water used, and for the amount of land used for food production. Residents in the urban area most frequently make trips for acquiring food and are the furthest away from water resources, but they have the

Table 6
Location of hospitals and healthcare centres in the rural area.

Settlement	Number of households	Hospital code	Hospital name	Location (subdistrict)	Number of households visited
Rural	321	1	Udon Thani Hospital	Mak Khaeng	143
		12	Chiang Phin Health Promoting Hospital	Chiang Phin	5
		14	Pak Dong Health Promoting Hospital	Phen	24
		15	Nong Hai Health Promoting Hospital	Nikhom Song Khro	19
		16	Sok Nam Khao Health Promoting Hospital	Nong Hai	1
		17	Kok Sa-at Health Promoting Hospital	Kok Sa-at	13
		18	Nong Wua So Hospital	Nong Wua So	29
		19	Sok Kae Health Promoting Hospital	Mueang Phia	5
		20	Sang Paen Health Center	Kut Chap	10
		21	Kut Chap Hospital	Kut Chap	60
		22	Kut Chap District Public Health Office	Kut Chap	12

Table 7
Average frequency, Range of distance, Range of volume and Average/Range cost for household usage and travel to different resources in each zone.

Urban								
Resource	Average frequency		Range of distance		Range of volume		Average/Range of cost	
Water			10–20	Km.	1–20	m^3/Month	Avg. = 276.05	Baht/Month
Food	2.5	Trip/week						
Hospital	1.57	Trip/month	1–5	Km./trip			Range = 20–500	Baht/Trip
Peri-Urban								
Resource	Average frequency		Range of distance		Range of volume		Average/Range of cost	
Water			10–15	Km.	1–30	m^3/Month	Avg. = 348.85	Baht/Month
Food					1–5	Rai		
Hospital	1	Trip/month	5–10	Km./trip			Range = 20–500	Baht/Trip
Rural								
Resource	Average frequency		Range of distance		Range of volume		Average/Range of cost	
Water			5–10	Km.	1–30	m^3/Month	Avg. = 367.69	Baht/Month
Food	3.5	Trip/Year			5–10	Rai	Avg. = 93,517.24	Baht/Year
Hospital	1.32	Trip/month	1–10	Km./trip			Range = 30–500	Baht/Trip

lowest cost of water and the shortest distance to hospitals, when compared to residents in the other areas. Meanwhile, households in the peri-urban and rural areas have a higher range of water usage, which is consistent with how they also use land for producing food. The information provided in this table offers additional insight into the lifestyles and behaviour of the respondents with regards to their access to resources.

3.2. Ranking of dependency level across urban-peri-urban-rural households

Tables 8–10 show the perceptions of residents regarding their dependencies on the urban and the rural areas for various facilities or resources, with 1 being low dependency and 5 being high dependency. The average rating is shown on the tables. The residents of urban areas mostly self-reported as being dependent on resources within the rural area, while the urban and peri-urban areas are more dependent on other areas. This highlights that the residents are aware of the interdependence between the urban and rural areas, which suggests that they are likely to understand the need for collaborating with other areas in order to tackle sustainability issues.

The household survey results of urban residents (Table 8) shows that they are more dependent on the following resources/facilities located in the urban area: Medical Service, Education, Workplace, Markets for agricultural products, and Investments for economic activities. They are more dependent on the rural area for resources relating to tourism, meaning that they prefer to go to the rural area rather than the urban area for tourism. The urban residents responded that they are dependent on both the urban and the rural areas for investments in water supply and management. Regarding food, the urban residents responded that they are more dependent on the urban area then they are on the rural area. This is likely because the respondents were considering places where they can buy food, such as markets, rather than the location in which their food was produced, which is the rural area.

The responses of the peri-urban residents (Table 9) shows that they depend mostly on the urban area medical service and educational resources. They self-reported that they depend on both the urban and rural areas for the resources of the workplace, markets for agricultural products and investments for economic activities, and that they depend on the urban area more for tourism, water resources investment and water management investment purposes. The peri-urban residents also responded that they depend more on the rural area for food resources. This could refer to the site of food production as well as the local markets which may be more easily accessible or more affordable than the markets in the urban area.

Residents of rural areas responded that they are self-reliant, as they depend more on the rural area than the urban area for all categories of resources (Table 10). This is because there are different resources in the

Table 8
Ranking of dependency level on different areas for 150 urban households.

Resources	Urban areas	Average (1–5)	Rural areas	Average (1–5)
1) Medical Service	134	3.5	1	2
2) Education	71	4.05	2	
3.) Workplace	111	4.16	4	4.33
4) Markets for agricultural products	49	3.49	34	2.45
5) Investments for economic activities	43	4.11	8	3.17
6) Tourism	42	2.74	35	3.25
7) Water supply investment	45	4.11	25	3.625
8) Water management investment	36	3.57	16	3.11
9) Food	128	4.61	11	3.9

Table 9
Ranking of dependency level on different areas for 100 Peri-urban households.

Resources	Urban areas	Average (1–5)	Rural areas	Average (1–5)
1) Medical Service	70	3.53	3	3.67
2) Education	18	4.22	6	4.17
3) Workplace	15	4	15	4.73
4) Markets for rural products	20	3.2	21	3.9
5) Investment for economic activities	13	4	8	4
6) Tourism	56	2.68	31	2.71
7) Water supply investment	20	4.1	1	4
8) Water management investment	20	4.1	1	4
9) Food	11	4.54	80	4.94

Table 10
Ranking of dependency level on different areas for 321 rural households.

Resources	Urban areas	Average (1–5)	Rural areas	Average (1–5)
1) Medical Service	70	3.97	111	3.54
2) Education	59	3.83	115	3.50
3) Workplace	46	3.76	127	3.50
4) Markets for rural products	29	3.61	151	3.70
5) Investment for economic activities	34	3.47	142	3.38
6) Tourism	54	3.33	112	3.16
7) Water supply investment	13	3.31	157	3.31
8) Water management investment	19	3.42	151	3.26
9) Food	19	3.63	158	3.73

rural area that offer various utilities, services, water and food resources, as well as tourist attractions.

3.3. Awareness and willingness of inhabitants

3.3.1. Perceptions on natural resource management

One of the objectives of this research is to understand the residents' awareness of urban-rural linkages in the area as well as their willingness or support for improving natural resource management in the region. The results are shown below in Tables 11 and 12. The surveys found that 21% of respondents in the urban area were not aware of where their water supply comes from, and 42% were not aware that households in the rural areas are also dependent on this source. The respondents assumed that the source is Nong Prajak Pond, the largest pond in the Udon Thani City Region, while most households in the urban and the *peri* urban zones, and even some households in the rural areas, receive potable water supply from the Provincial Waterworks Authority (PWA) which drew most of the water from the Huai Luang Reservoir. This indicates a low level of awareness regarding water resource management and dependency.

The surveys also examined the respondents' awareness of the importance of natural resources and their willingness to contribute to natural resource management. Before completing the survey, the respondents receive a brief explanation about sustainability. In the urban area, most respondents agreed that urban expansion would affect the natural resources, particularly water and food supply. Increased demand for water in the city can lead to the decrease in the amount of water available for environmental maintenance and agricultural purposes, and could therefore lead to reduced agricultural productivity and increased food prices and insecurity. Participants in the urban area expressed that they were willing to participate in natural resource management activities and agreed that the residents of the urban area must do something to improve the environment and contribute to the betterment of the whole City Region.

In the Peri-urban area, the respondents viewed urban expansion as a positive phenomenon because it could bring employment opportunities as well as better amenities. However, most respondents expressed that they are concerned about the increased demand for water, and some state that they are already feeling the effects of water scarcity. The proportion of respondents with a positive view of urbanisation is smaller in the urban area, with many respondents expressing concerns about the negative impact of urbanisation on the agricultural sector.

3.4. Food production and distribution

Most of the survey participants from the rural zone were farmers who own agricultural land ranging from 8000 to 32,000 square metres (0.8 to 3.2 ha.). Their main agricultural products are rice, cassava, Pará rubber, sugarcane, and vegetables. The survey results show that the communities in the rural zone were quite independent of each other with regards to food supplies, as most of them produce most of the food that they need. Most of the agricultural products from the rural zone are sent to the city for distribution, which means that the livelihood of communities in the rural area depends heavily on businesses, warehouses and transport hubs in the urban area. Some agricultural products such as sugarcane and cassava are also sent to food processing facilities elsewhere in Thailand or abroad.

Meanwhile, participants from the urban and peri urban zones did not produce their own food. Most buy food from the markets or supermarkets, and do not buy produce directly from producers in the *peri*-urban or rural areas. Participants in the urban and peri urban zones often did not have awareness about where their food originated from. Figs. 3 and 4 show the location of the markets and supermarkets that are commonly used by the surveyed communities, and Table 2 shows the frequency of procurement of different food items.

3.5. Infrastructure and utility dependencies

The survey results show that respondents in the urban, *peri*-urban, and rural zones were independent of each other when it comes to commuting, which suggests that they are quite self-sufficient with regards to the availability of essential infrastructure and services in their area. Respondents in the urban zone stated that they live within five kilometres distance from hospitals (particularly Udon Thani Hospital), clinics, or other

Table 11
Awareness of respondents in the urban area towards natural resources and their willingness to contribute to natural resource management activities.

	Awareness and willingness of respondents in the urban area towards natural resources and their management	Yes	No
1	Are you aware that the water supplied to your area is augmented from the Huai Luang reservoir?	110 (79%)	30 (21%)
2	Are you aware that many rural and forest areas are dependent on the same source?	80 (58%)	57 (42%)
3	Are you aware of the water issues in forest and rural areas adjoining Udon Thani city?	76 (56%)	59 (44%)
	If yes, how?		
	a. through visual media	68 (64%)	
	b. through print media	11 (10%)	
	c. through personal visit	20 (19%)	
	d. others (specify)	7 (7%)	
4	Do you feel that increased water demand in the city is contributing to crisis situations in forest & rural areas?	126 (91%)	12 (9%)
5	Are you aware that rural areas are supplying food to urban areas?	84 (88%)	11 (12%)
6	Do you feel urban areas must contribute to the betterment of these forests and rural areas?	119 (90%)	13 (10%)
7	Are you practising any water conservation measures at household/ community level?	111 (83%)	22 (17%)
8	Which type of development do you support?		
	a. Sustainable Rural	11 (7%)	
	b. Sustainable Urban	13 (9%)	
	c. Sustainable Urban-Rural	127 (84%)	
9	Are you willing to contribute and take part in natural resource management activities?	107 (83%)	22 (17%)
	If yes, how?		
	a. Watershed development measures	23 (14%)	
	b. Operation and maintenance	22 (13%)	
	d. Conservation	78 (47%)	
	4. Awareness creation/ Knowledge sharing	42 (25%)	
	If not, who else should contribute to water resource management?		
	a. Community waterworks	29 (18%)	
	b. Provincial Waterworks	51 (31%)	
	c. Irrigation department	37 (23%)	
	d. NGO	23 (14%)	
	e Community and related organisations	22 (14%)	

Table 12
Perception of respondents in rural settlements towards water resources and their management.

	Perception of respondents in rural settlements towards water resources and their management	Yes	No
1	What is the impact of urbanisation on agriculture land use change?		
	a. Positive	185 (57%)	
	b. Negative	59 (18%)	
	c. No effect	78 (24%)	
	Positive		
	a. Increased access to market	117 (25%)	
	b. Improved services	77 (16%)	
	c. Livelihood opportunities	136 (29%)	
	d. Increasing land-value	141 (30%)	
	e. Others	4 (1%)	
	Negative		
	a. Reducing agricultural fields	59 (27%)	
	b. Reducing agricultural production	58 (27%)	
	c. Reducing agriculture labourers	88 (41%)	
	e. Others	11 (5%)	
2	Do you think that expansion of urban area increase pressure on water resources of your area	127 (43%)	166 (57%)
	a.Scarcity of water for domestic	78 (55%)	
	b.Scarcity for water for irrigation	65 (45%)	
3	What kind supports you expect from urban area for mitigation water management challenges		
	a. Financial compensation	67 (23%)	
	b. Support for management of watershed	82 (29%)	
	c. Support to improve water use efficiency	137 (48%)	

Fig. 3. A proposal for the Udon Thani City Region CES Platform created at the stakeholder consultation workshop.

healthcare centres. Respondents in the peri urban zone also did not have to travel far to healthcare facilities. Respondents in the rural zone have to travel to the urban zone to seek certain medical care, but they can also receive minor medical care from smaller sub district hospitals. With regards to travelling for educational purposes, most participants responded that they commuted between one to five kilometres away from their residences to send their children to schools. Only a few participants stated that they were willing to travel a long distance to have their children in famous or prestigious schools and universities. None of the respondents stated that they experience significant problems in commuting to work.

3.6. Stakeholder consultation workshop

The stakeholder workshop revealed that the invited stakeholders were receptive to the R-CES concept which is in line with some of the observations that they have made about the challenges that the province faces.

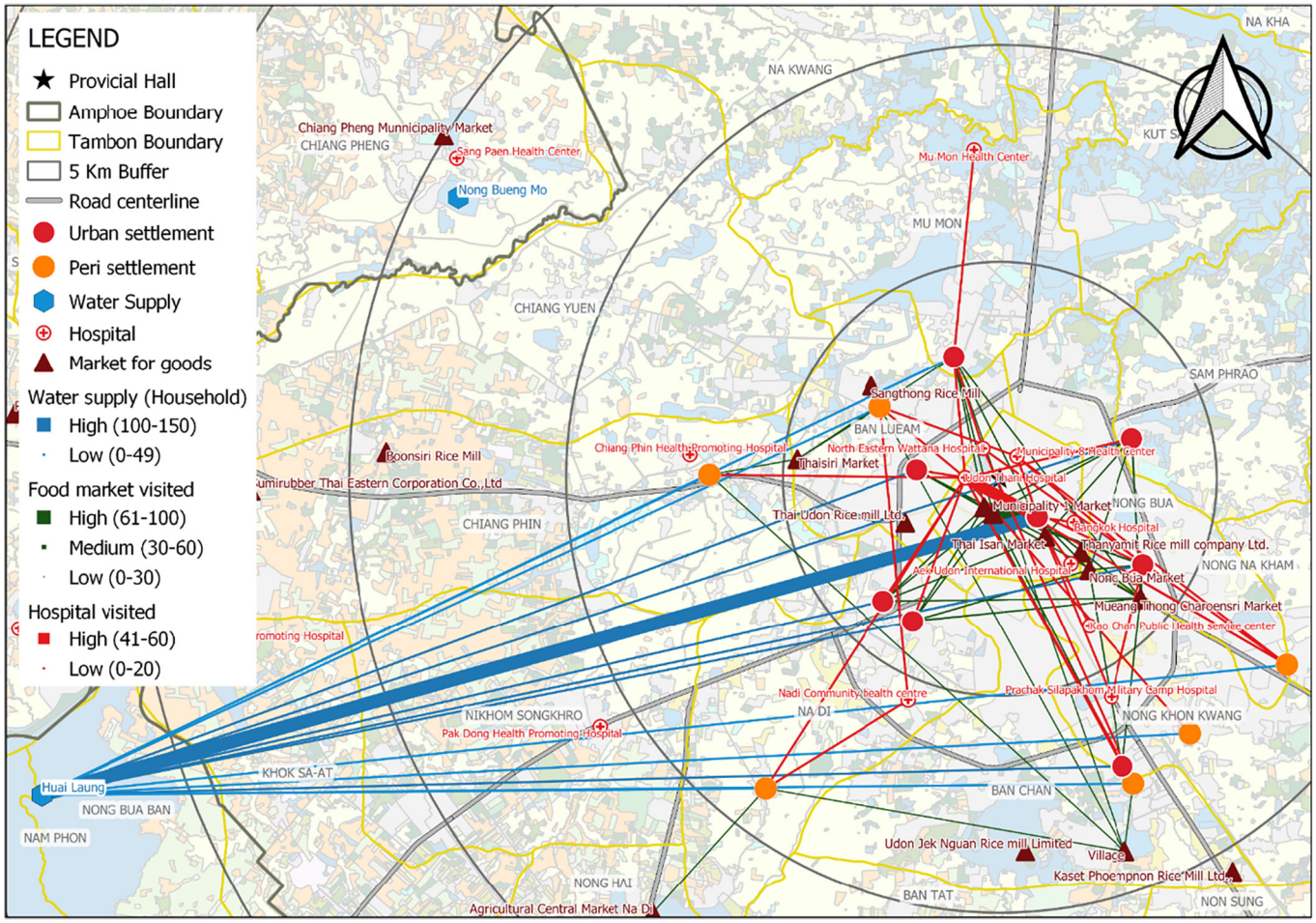

Fig. 4. Map showing the flows of food and water and hospital of urban and peri-urban households.

The stakeholders present at the workshop agreed that one of the main problems that hinder the province's development is the risk of flood and water shortages. Some participants expressed that these issues are exacerbated by how the local government agencies only work within their boundaries and rarely collaborate meaningfully with other organisations. They also acknowledged that the urban, peri-urban and rural areas are interconnected and that the shared resources that they use are essential to the development of the Udon Thani city region.

The stakeholders expressed that they would like to take action based on this consultation workshop, which suggests that the R-CES concept was useful as a guide for strategic policy planning and in encouraging engagement. Participants from Udon Thani municipality, Udon Thani Provincial office and various community-based organisations agreed that successful Urban-Rural partnership can be facilitated through steering teams. The Udon Thani Provincial authority could function as the central coordinating body that engages all the stakeholders and local communities to promote the Urban-Rural partnership according to the Regional-CES framework. The Provincial Administrative Organisations could be part of the second team to promote plans and strategies to the local organisations as well as managing the budgets. Lastly, there should be a technical expert team of local institutions and academia, who could provide insights regarding governance.

4. Discussions

Under the CES framework, it is important to understand the flow of resources as well as the dependencies between the urban and rural areas. The first objective of this research is to provide information on the resource flows between the urban, peri-urban and rural areas in Udon Thani province, which could provide guidance for future development policies or plans, as well as for guiding the province's development towards achieving R-CES. The findings of the household survey demonstrate that the urban-rural linkages in Udon Thani exhibit dependencies in the dimensions of food and water security, and that individuals in the region travel between the urban and rural areas for infrastructure and recreational reasons.

Firstly, the research highlights how water security is an issue that needs to be prioritised in order to ensure the resilience of the Udon Thani city region. As an area with a high concentration of built structures and economic activities, the urban area does not have the space for food production or water management facilities. The urban and the peri-urban areas are both dependent on the rural area for water, with the majority of households drawing their potable water from the Huai Luang Reservoir. This suggests that there should be collaboration between the rural and urban and peri-urban areas with regards to water management, as authorities in the rural area influence the quality and maintenance of the water source, and the increased demand for water as a result of population growth, urbanisation and increase in activities in the urban and peri-urban areas can affect the availability of water for both areas. The province should also consider finding an alternative source of water in order to enhance the water security in the region. On the other hand, the rural area is more self-reliant in terms of water supply; most of the households in the rural areas own agricultural land and rely on water ponds, local reservoirs and groundwater for their household consumption as well as agricultural activities. Rural communities are more reliant on natural resources that are found near their homes or farms, and are sensitive to changes in the groundwater table. Habitants of the rural communities will therefore be severely affected if the

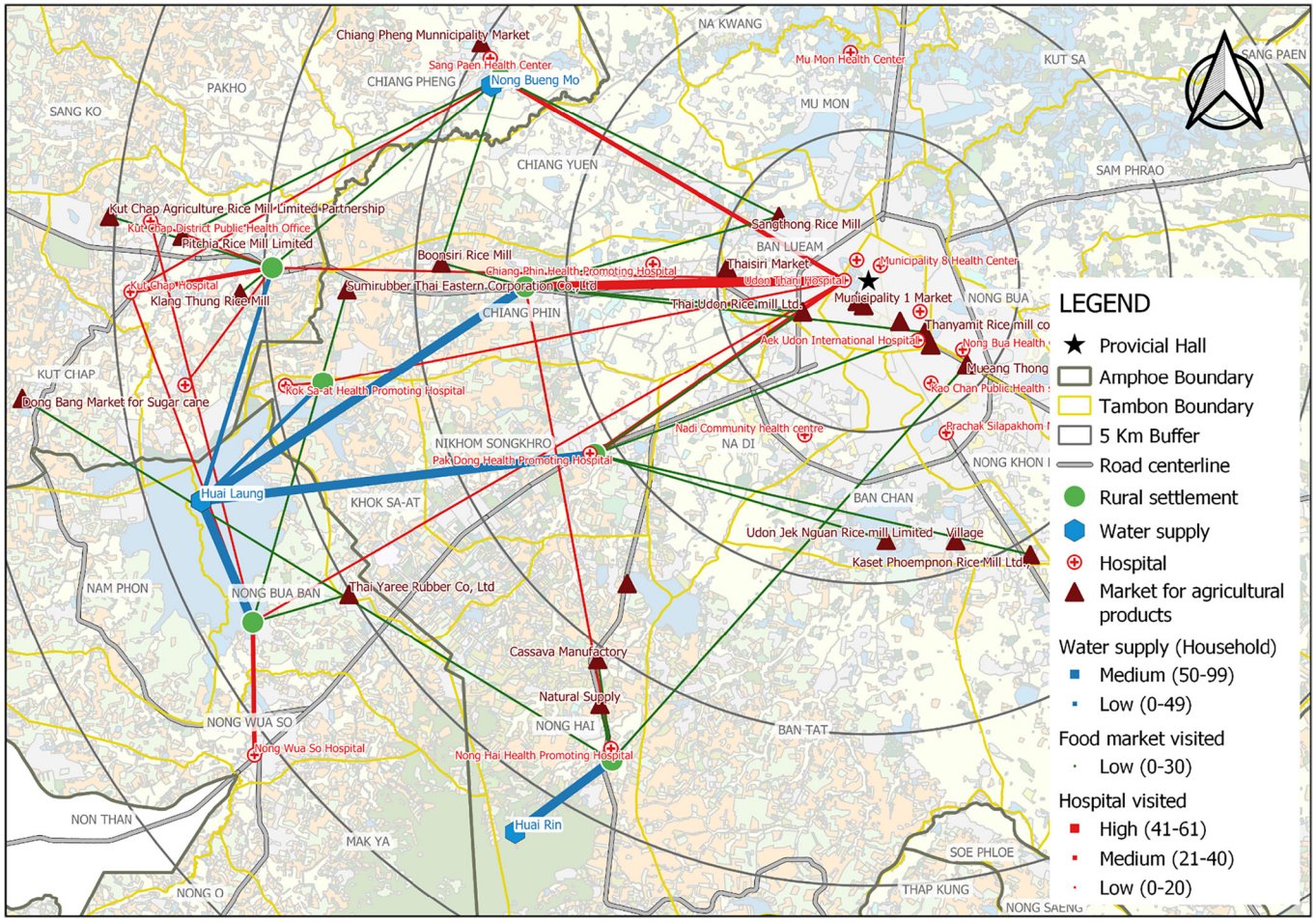

Fig. 5. Resource flows of food, water and hospital of rural households.

authorities in Udon Thani decide to exploit groundwater resources as an alternative source of water for accommodating increased demand for water from urban areas, which would deprive them of water security. This suggests that an alternative water source for the urban and peri-urban area may be necessary.

Secondly, the research found that there are also linkages regarding food security. Residents of the urban and the peri-urban areas rely on the rural area for fresh produce, which they buy from local markets. Only residents of the rural areas are self-sufficient in terms of food supply, as shown by how they rarely buy food that is not locally produced. However, while there are some factories and cassava manufacturing plants in the rural and peri-urban areas, residents of the rural areas are dependent on markets and transport hubs in the urban zone for the sale and distribution of their produce. Any changes in the demands of the people in the city or any projects involving transportation networks will therefore impact the farmers in the rural areas. To enhance the self-reliance and economic sustainability of the rural area, it could be beneficial to create distribution centres or purchasing hubs in the rural area, which would allow for more farmers to be able to sell their produce without requiring a middleman. Moreover, as water is required for agriculture, food security in the region may be threatened if there is water insecurity. This further emphasises the need to ensure sustainable management of water resources.

The second objective of this research is to examine the level of the residents' awareness of urban-rural interdependencies and whether they would be likely to support urban-rural partnerships for sustainable development purposes. The level of awareness and willingness to support development policies is crucial to the application of R-CES as the concept highlights the importance of collaboration and participation for sustainable resource management [5]. The survey shows that the majority of respondents are aware of how the urban, peri-urban and rural areas are interconnected and interdependent as shown by how they responded to the survey that they are concerned about the effects of urban growth and expansion on local food and water shortages. These responses suggest that there is a potential for local engagement for environmental protection as well as likely public support for policies that allow for the comprehensive management of resources and systems at the city region scale. Moreover, the discussions and action plans from the stakeholder consultation workshop indicate that the stakeholders, including government authorities, are receptive to the concept of R-CES, which suggests that there is potential for the R-CES concept to be applied in Udon Thani province. Ultimately, the extent to which R-CES will be able to influence the trajectory of development planning in Udon Thani depends on how receptive policy makers are to the concept. Additional research would be required to ensure successful implementation of this concept, such as the creation of indicators and assessment methods that will measure and quantify the progress made, and to identify the unique social, economic and environmental characteristics that Udon Thani city region can utilise for enhancing sustainability and enhancing resilience.

5. Conclusions

Udon Thani is a province that is experiencing urban and economic growth. This research on the Udon Thani city region examines the opportunities for enhancing sustainability through the improvement of resource flows management and the strengthening of urban-rural linkages according to the R-CES concept. The research shows that the urban-rural linkages in

Udon Thani are characterised by how the urban area depends on the rural area for food and water security; meanwhile the rural area, which is mostly self-reliant in terms of water and food, depends on the urban area for economic purposes. The analysis of water resource management also showed that increased urban growth and increased demand for water from the urban area would adversely affect agriculture in the rural area, which is something that requires attention in order to maintain food security. There is also significant movement of people between these areas.

The findings therefore highlight the importance of ensuring that there is a holistic territorial development plan for the province because the urban, peri-urban and rural areas are interdependent. In order to become more resilient, especially to possible risks arising from climate change and urban expansion which can reduce the availability of water as well as food security, it is important that the urban-rural linkages are strengthened [16–18]. There is opportunity collaboration that is based on the nature of dependency between the urban and rural areas: for example, the urban area may offer financial support for farmers in the rural area for actions that will help protect the quality of Huai Luang reservoir, which is located in the rural area but is used mostly by the urban dwellers. The findings of the research also suggest ways in which the different areas could enhance their self-reliance according to R-CES. For example, farmers in the rural area could benefit from having distribution centres or produce processing plants in the rural area, which could allow them to sell their produce without having to go through middlemen in the urban area.

Another objective of the research was to examine the level of awareness and willingness of the survey respondents to participate in resource management for increased sustainability and resilience in Udon Thani. The results indicate that the residents in the urban, peri-urban and rural areas all have moderate awareness about sustainability and resource management, and that the majority of respondents demonstrated support for improved resource management. This suggests that there is a possibility for collaborative, bottom-up engagement for sustainability.

The potential applicability of R-CES as a guiding concept for development policy was also supported by the feedback received from relevant stakeholders who are aiming to implement principles of R-CES in the upcoming strategic plan for Udon Thani, which suggests that R-CES could be useful concept that can be applied to this specific context.

Furthermore, the collaboration between different government entities and policymakers will create a shared understanding and vision regarding natural resource management, as well as for knowledge exchange between different jurisdictions. It would be beneficial to invest in the analyses on land use and the future demand and supply of natural resources in the future to enhance development planning, as well as to use R-CES as a guiding principle for strengthening local resources and developing the tourism sector in order to enhance economic sustainability.

It would be interesting to extend this research to a wider study area in the Udon Thani province to have an even more comprehensive understanding of the region, as well as to involve a larger sample size. There are also opportunities to expand this research by also examining the flows of energy and waste, in addition to water and food.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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References

[1] UN-Habitat. Implementing the New Urban Agenda by strengthening urban-rural linkages: Leave no one and no space behind. Nairobi, Kenya: United Nations Human Settlements Programme; 2017.
[2] Neuman Michael, Hull Angela. The futures of the city region. Reg Stud. 2009;43(6):777–87. https://doi.org/10.1080/00343400903037511.
[3] Bafarasat Abbas Ziafati. "Theorizing" regime theory: a city-regional perspective. J Urban Aff. 2018;40(3):412–25. https://doi.org/10.1080/07352166.2017.1360729.
[4] Rodríguez-Pose A. The rise of the "City-region" concept and its development policy implications. Eur Plan Stud. 2008;16. https://doi.org/10.1080/09654310802315567.
[5] IGES. Circulating and ecological economy – Regional and local CES: An IGES proposal. Accessed online on 15 October 2021 via. https://www.iges.or.jp/en/publication_documents/pub/discussionpaper/en/6744/Circulating+and+Ecological+Economy+-+Regional+and+Local+CES%2C+An+IGES+Proposal.pdf; 2019.
[6] Ministry of the Environment, Government of Japan. Creation of a regional circular and ecological sphere (regional CES) to address local challenges. Accessed online on 15 October 2021 via. https://www.env.go.jp/en/wpaper/2018/pdf/04; 2018.
[7] Schöggl Josef-Peter, Stumpf Lukas, Baumgartner Rupert J. The narrative of sustainability and circular economy – a longitudinal review of two decades of research. Resour Conserv Recycl. 2020;163:105073.
[8] Ministry of the Environment, Government of Japan. The basic environment plan. Accessed online on 15 October 2021 via. https://www.env.go.jp/policy/kihon_keikaku/plan/plan_5/attach/ref_en-01.pdf; 2019.
[9] Thapa K, Sukhwani V, Deshkar S, Shaw R, Mitra BK. Strengthening urban-rural resource flow through regional circular and ecological sphere (R-CES) approach in Nagpur. India Sustain. 2020;12:8663. https://doi.org/10.3390/su12208663.
[10] Ortiz-Moya F, Kataoka Y, Saito O, et al. Sustainable transitions towards a resilient and decentralised future: Japan's Circulating and Ecological Sphere (CES). Sustain Sci. 2021;16:1717–29. https://doi.org/10.1007/s11625-021-00941-y.
[11] Swerts E, Denis E. Megacities: The Asian era. In: Singh RB, editor. Urban development challenges, risks and resilience in Asian mega cities. Springer: Essay; 2015. p. 1–28.
[12] Marome W, Natakun B, Archer D. Examining the use of serious games for enhancing community resilience to climate risks in Thailand. Sustainability. 2011;13:4420. https://doi.org/10.3390/su13084420.
[13] United Nations Human Settlement Programme. (n.d.). UN-HABITAT for a better urban future: Resilience and risk reduction. https://unhabitat.org/topic/resilience-and-risk-reduction
[14] Marome W. Coping with scarcity and urban water governance: Case of Udon Thani's city region. Urban drought: Emerging water challenges in Asia. Singapore: Springer; 2019. p. 87–100.
[16] Forster T, Santini G, Edwards D, Flanagan K, Taguchi M. Strengthening urban rural linkages through city region food systems: UNCRD/UN Habitat issue of re-gional development dialogue, Vol. 35 on urban-rural linkages in support of the new urban agenda; 2015.
[17] Caffyn A, Dahlström M. Urban–rural interdependencies: joining up policy in practice. Reg Stud. 2005;39(3):283–96. https://doi.org/10.1080/0034340050086580.
[18] Akkoyunlu S. The potential of rural–urban linkages for sustainable development and trade. Int J Sustain Dev World Policy. 2015;4(2):20–40. https://doi.org/10.18488/journal.26/2015.4.2/26.2.20.40.