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Key global challenges and opportunities for scaling up upcycling businesses in the world: Interpretive structural modelling workshop preliminary analysis

Amal Abuzeinab[(a)], Kyungeun Sung[(a)], Richie Moalosi[(b)], Ashwathy Satheesan[(c)], Bilkisu Garba[(d)], Funto Adeh[(d)], Hye-Won Lim[(e)], Joon Sang Baek[(f)], Sophia N. Njeru[(g)]
a) De Montfort University, Leicester, UK
b) University of Botswana, Gaborone, Botswana
c) Fractal, Bengaluru, India
d) The Upcycle Architect, Abuja, Nigeria
e) University of Leeds, Leeds, UK
f) Yonsei University, Seoul, South Korea
g) Kirinyaga University, Kerugoya, Kenya

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Abstract: Upcycling is one promising approach to extending the lifetimes of products, components, and materials by utilising a variety of material processes and innovations to turn waste products and materials into products of higher quality or value than the compositional elements. Upcycling increases resource efficiency and reduces solid waste and industrial energy consumption. It creates new job opportunities for businesses and reduces costs for materials. Despite such benefits, however, upcycling remains a niche practice. Moving from a niche to a mainstream practice (or scaling-up) could realise the full potential of upcycling. Understanding interrelated and self-reinforcing challenges in the global upcycling value chain is critical for scaling up global upcycling businesses. As existing studies of upcycling are mostly industry and country-specific, the factors impacting upcycling success across industries and countries still need to be discovered, making it difficult to establish which challenges can be prioritised in effectively scaling up upcycling businesses internationally. This study aimed to identify critical global challenges and opportunities for scaling up upcycling businesses worldwide. We organised two online workshops with nine international experts in upcycling, utilising Interpretive Structural Modelling (ISM). The preliminary analysis of the ISM workshop results showed that all global challenges and opportunities are interlinked and that key opportunities reflect key challenges, with the first priority intervention suggested as 'involving citizens in upcycling initiatives or events' followed by 'improving material provision'.

Introduction

Upcycling is one of the promising approaches to extending the life span of products, components and materials by utilising various material processes and innovations to transform used or waste products, components and materials into a product/material of higher quality or value than the compositional elements (Sung, 2017). Examples include 'creative' or 'advanced' forms of repair, reuse, repurpose, refurbishment, upgrade, redesign, remake, remanufacture, and recycling – within the remit of the circular economy, an alternative to the traditional linear economy of take, make use, and dispose (Stahel, 2016). The extended life span of used/waste products, components and materials by upcycling increases resource efficiency and reduces solid waste and industrial energy consumption in processing and manufacturing with virgin materials. Upcycling also creates new job opportunities for businesses and reduces material costs. Despite such benefits, however, upcycling remains a niche practice (Sung, Singh, & Bridgens, 2021). Moving from a niche to a mainstream practice or scaling up could lead to the full potential of upcycling. Understanding interrelated and self-reinforcing challenges in the global upcycling value chain are critical for scaling up global upcycling businesses. For

example, consumers' negative perception of upcycled products affects the demand, which affects the price, and, therefore, sales, leading to a limited market resulting in few available good quality products that feedback into consumers' adverse perception of upcycled goods in fashion and furniture sectors (Singh, Sung, Cooper, West, & Mont, 2019). Existing studies of upcycling are mostly industry and country-specific (e.g., Cumming, 2017; Paras & Curteza, 2018; Singh et al., 2019). The factors impacting upcycling success across industries and countries are largely unknown, making it difficult to establish which challenges can be prioritised in effectively scaling up upcycling businesses internationally.

This study aimed to identify critical global challenges and opportunities for scaling up upcycling businesses worldwide. We initially conducted a literature review to identify global challenges and opportunities for scaling up upcycling. We used online questionnaires to narrow down the factors into six. Then, we organised two online expert workshops to prioritise the factors, further explained in detail in the following section.

Methods

Literature review

The initial literature review to identify global challenges and opportunities for scaling up upcycling was conducted between February and March 2021, resulting in nine common categories of challenges and ten common opportunities for successful upcycling across industries and countries. Please find the details in the review paper published as a book chapter (Sung & Abuzeinab, 2021).

Online questionnaire

We created an online questionnaire from the literature review to ask the study participants to select up to six key global challenges and opportunities for scaling up upcycling businesses. The answer options provided for global challenges were: (i) difficulty in sourcing materials, (ii) limitations from the materials (e.g. inconsistency, damage), (iii) lack of facilities or equipment, (iv) time-consuming processes, (v) limited knowledge and skills, (vi) limited good quality products, (vii) high sale price, (viii) difficult and expensive promotion/marketing activities, (ix) limited, affordable space, (x) financial constraints, (xi) limited legislation, standards, and warranty, (xii) consumers' negative perception of upcycled products, (xiii) consumers' low awareness of upcycling, and (xiv) other.

The answer options for global opportunities were: (i) improved material provision, (ii) suitable technologies, techniques, and innovation in production, (iii) targeting high-opportunity product categories, (iv) effective marketing, (v) support for the better mobilisation of resources and knowledge, (vi) financial support and incentives, (vii) varied stakeholder involvement (e.g., large brands, local authorities), (viii) awareness-raising training and education for consumers, (ix) involving citizens in upcycling initiatives or events, (x) awareness-raising campaign and communication, and (xi) other.

The online questionnaire was sent to 21 people interested in participating in the study within the International Upcycling Research Network funded by UKRI (UK Research and Innovation) AHRC (Arts and Humanities Research Council). Out of 21 people, 14 responses (67% response rate) were collected between July and August 2022. The respondents were nine academics and five practitioners with expertise in upcycling from 12 countries in five continents (Africa, Asia, Australia, Europe, and South America). The results showed that the majority of global upcycling experts (minimum 50%) agreed with six key global challenges and opportunities for scaling up upcycling businesses (Table 1).

Key global challenges
C1. Limitations from the materials (e.g., inconsistency, damage)
C2. Lack of facilities/equipment
C3. Time-consuming processes
C4. Consumers' low awareness of upcycling
C5. Consumers' negative perception of upcycled products
C6. Limited legislation, standards, and warranty
Key global opportunities
O1. Improved material provision
O2. Targeting high-opportunity product categories
O3. Suitable technologies, techniques, and innovation in production
O4. Varied stakeholder involvement (e.g., large brands, local authorities)
O5. Involving citizens in upcycling initiatives/events
O6. Awareness-raising activities (e.g., campaign, communication, training, education)

Table 1. Key global challenges and opportunities for scaling up upcycling businesses

Interpretive Structural Modelling online workshops

Using the online questionnaire results (Table 1), we prepared for the Interpretive Structural Modelling (ISM) online workshops. ISM is a qualitative and interpretive method used to structure various factors into a hierarchy based on the importance of the factors and visualise the interaction between these factors to help decision-makers in tackling these factors in order (Abuzeinab, Arif & Qadri, 2017; Attri, Dev & Sharma, 2013). Two online workshops were organised in September 2022. The workshop invitation was sent to the same 21 AHRC-funded International Upcycling Research Network members who expressed their interest in the study participation (who also received the online questionnaire). Nine international experts in upcycling participated in the workshops. They were academics and practitioners from seven countries (Botswana, Kenya, India, Nigeria, South Africa, South Korea, and the UK) covering three continents (Africa, Asia and Europe).

At the beginning of the workshop, the facilitator explained the aim and objectives of the workshop and procedures. The main workshop was organised so that the facilitator presented each factor (challenge or opportunity) with other factors and asked the participants whether the presented factor would influence other factors. Individual opinions were collected, and group agreement was sought. For data collection, notes were taken on the main points and agreement, and the workshops were video recorded with the participants' consent. The data were analysed by developing SSIM (Structural Similarity Index) and RM (Reachability Matrix), and MICMAC (cross-impact matrix multiplication applied to classification) analysis (Nilashi, Dalvi, Ibrahim, Zamani & Ramayah, 2019).

Results

Key global challenges

Four symbols were used to denote the direction of the relationship between any two global challenges (i and j):

- V: challenge i will influence challenge j, but not in both directions.
- A: challenge j will influence challenge i, but not in both directions.
- X: challenge i and j will influence each other.
- O: challenge i and j are unrelated.

See Table 2 for the SSIM (Structural Similarity Index) and Table 1 for C1 to C6.

	C1	C2	C3	C4	C5	C6
C1		X	X	A	A	X
C2			X	A	X	X
C3				X	V	X
C4					X	X
C5						X
C6						

Table 2. SSIM for global challenges

The RM (Reachability Matrix) was obtained by converting the SSIM into a binary matrix by substituting V, A, X, and O with 1 and 0 as per the case. The rules for the substitution of 1s and 0s are the following:

- if the (i, j) entry in the SSIM is V, then the (i, j) entry in the reachability matrix becomes 1, and the (j, i) entry becomes 0.
- if the (i, j) entry in the SSIM is A, then the (i, j) entry in the reachability matrix becomes 0, and the (j, i) entry becomes 1.
- if the (i, j) entry in the SSIM is X, then the (i, j) entry in the reachability matrix becomes 1, and the (j, i) entry also becomes 1.
- if the (i, j) entry in the SSIM is O, then the (i, j) entry in the reachability matrix becomes 0 and the (j, i) entry also becomes 0.

Driving power and dependence scores are the sums in rows and columns (Table 3).

	C1	C2	C3	C4	C5	C6	Driving power
C1	1	1	1	0	0	1	4
C2	1	1	1	0	1	1	5
C3	1	1	1	1	1	1	6
C4	1	1	1	1	1	1	6
C5	1	1	0	1	1	1	5
C6	1	1	1	1	1	1	6
Dependence	6	6	5	4	5	6	32/32

Table 3. RM matrix for global challenges

Based on the RM matrix, MICMAC analysis classified global challenges as seen in Figure 1. The major findings of this classification are as follows:

- The diagram indicates that no challenge comes under an autonomous cluster. Autonomous challenges generally appear as weak drivers, weakly dependent and relatively disconnected from the system. These challenges have little influence on other challenges of the system.
- There are also no dependent challenges. The dependent challenges mean other challenges need to be addressed and moved before their removal.

- There were also no challenges within the driver cluster. Driver challenges will have strong driving power but weak dependence power. Driver challenges need to be addressed first and they can influence all other challenges.
- All challenges are within the linkage cluster. Linkage challenges have a strong driving power as well as strong dependence. These challenges are unstable because any action on them will affect others and have a feedback effect on themselves.

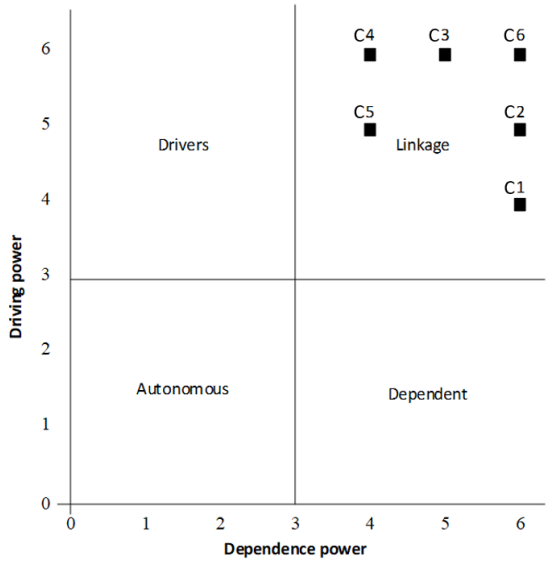

Figure 1. MICMAC analysis for global challenges

Table 4 shows the partitioning of the RM into different levels (iterations 1 to 3).

Challenge	Reachability set	Antecedent set intersect	Intersection set	Level
Iteration 1				
C1	C1,2,3,6	C1,2,3,4,5,6	C1,2,3,6	1st
C2	C2,1,3,5,6	C2,1,3,4,5,6	C2,1,3,5,6	1st
C3	C3,1,2,4,5,6	C3,1,2,4,6	C3,1,2,4,6	
C4	C4,1,2,3,5,6	C4,3,5,6	C4,3,5,6	
C5	C5,1,2,4,6	C5,2,3,4,6	C5,2,4,6	
C6	C6,1,2,3,4,5	C6,1,2,3,4,5	C6,1,2,3,4,5	1st
Iteration 2				
C3	C3,4,5	C3,4	C3,4	
C4	C4,1,5	C4,3,5	C4,5	
C5	C5,4	C5,3,4	C5,4	2nd
Iteration 3				
C3	C3,4	C3,4	C3,4	3rd
C4	C4,1	C4,3	C4	

Table 4. RM into levels for global challenges

From the analyses including the levels determined, the ISM model was developed for global challenges (Figure 2). The model shows that all the challenges are interlinked – arrow directions denoted the relationship. The model was structured on four levels. At the base of the structure, 'consumers' low awareness of upcycling' will need to be addressed before moving up to level 3 (C3: 'time-consuming processes') and level 2 (C5: 'consumers' negative perception of upcycled products'). Three challenges at the top of the structure (C1: 'limitations from the materials', C2: 'lack of facilities/equipment', and C6: 'limited legislation, standards, and warranty') can be addressed at the end.

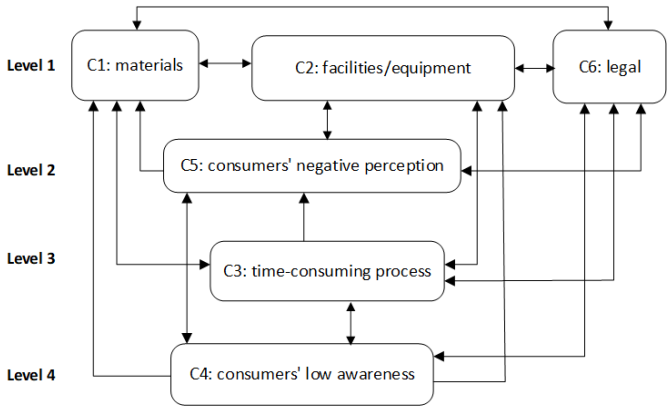

Figure 2. ISM model for global challenges

Key global opportunities

SSIM for global opportunities was developed using the same approach for global challenges (Table 5). See Table 1 for O1 to O6. Then, the RM was obtained using the same approach for global challenges (Table 6).

	O1	O2	O3	O4	O5	O6
O1		V	X	X	X	X
O2			X	X	X	A
O3				X	A	A
O4					X	X
O5						X
O6						

Table 5. SSIM for global opportunities

	O1	O2	O3	O4	O5	O6	Driving power
O1	1	1	1	1	1	1	6
O2	0	1	1	1	1	0	4
O3	1	1	1	1	0	0	4
O4	1	1	1	1	1	1	6
O5	1	1	1	1	1	1	6
O6	1	1	1	1	1	1	6
Dependence	5	6	6	6	5	4	32/32

Table 6. RM matrix for global opportunities

MICMAC analysis based on the RM matrix classified global opportunities (Figure 3). There

are no autonomous, dependent or driver opportunities; all the opportunities are within the linkage cluster (just like challenges), showing strong driving power as well as strong dependence.

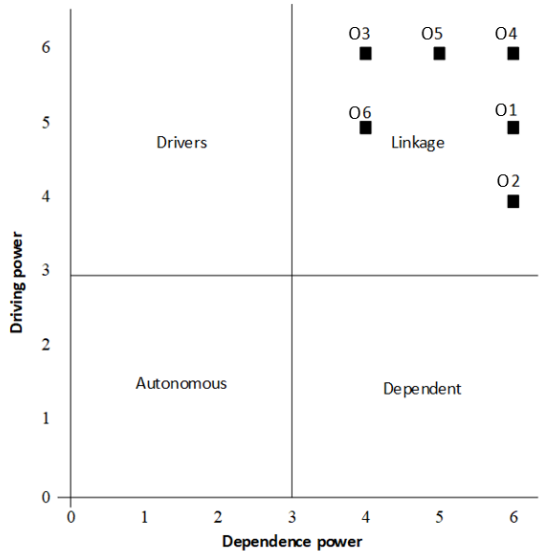

Figure 3. MICMAC analysis for global opportunities

Table 7 shows the partitioning of the RM into different levels (iterations 1 and 2), from this, the ISM model was developed for global opportunities (Figure 4).

Challenge	Reachability set	Antecedent set intersect	Intersection set	Level
Iteration 1				
O1	O1,2,3,4,5,6	O1,3,4,5,6	O1,3,4,5,6	
O2	O2,3,4,5	O2,1,3,4,5,6	O2,3,4,5	1st
O3	O3,1,2,4	O3,1,2,4,5,6	O3,1,2,4	1st
O4	O4,1,2,3,5,6	O4,1,2,3,5,6	O4,1,2,3,5,6	1st
O5	O5,1,2,3,4,6	O5,2,4,6	O5,2,4	
O6	O6,1,2,3,4,5	O6,1,4,5	O6,1,4,5	
Iteration 2				
O1	O1,5,6	O1,5,6	O1,5,6	2nd
O5	O5,1,6	O5,6	O5,6	3rd
O6	O6,1,5	O6,1,5	O6,1,5	2nd

Table 7. RM into levels for global opportunities

The model (Figure 4) shows that all the opportunities are interlinked (relationships indicated with the arrow directions). The model was structured on three levels. At the base of the structure, O5: 'involving citizens for upcycling initiatives/events' will need to be prioritised at the start before moving up to level 2 (O1: 'improved material provision' and O6: 'awareness-raising activities') and then level 1 (O2: 'targeting high-opportunity product categories', O3: 'suitable technologies, techniques, and innovation in production', O4: 'varied stakeholder involvement').

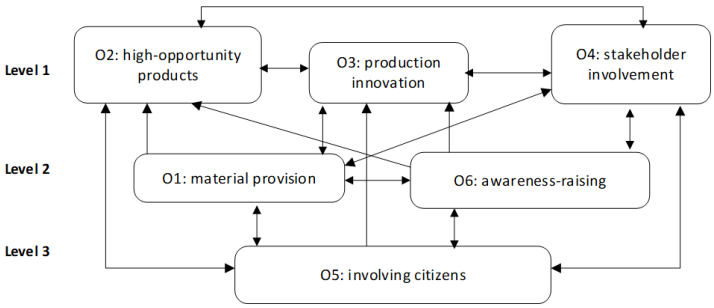

Figure 4. ISM model for global opportunities

Discussion and conclusions

The results showed that all key global challenges and opportunities are interlinked (within the category) and that key opportunities reflect key challenges. For example, the most important opportunity was 'involving citizens in upcycling initiatives/events' (Level 3 in Figure 4) when the most important challenge appeared to be 'consumers' low awareness of upcycling' (Level 4 in Figure 2). Although, this is still a preliminary analysis result based on the contributions by the nine international experts within the AHRC-funded International Upcycling Research Network. We are organising the third ISM workshop in person during the PLATE (Product Lifetimes And The Environment) Conference 2023. The third workshop involving other global experts in sustainable production and consumption (outside the network project) will validate these findings. As a limitation of this study, we are aware that the approach we used (bundling all data) does not necessarily reflect different contexts. Our approach also does not allow comparative analysis between different countries or continents. But the main point of this study is to identify the key global challenges and opportunities regardless of contextual differences.

Assuming that these results are more or less correct, the following practical implications could be derived. As both ISM models showed (Figures 2 and 4), the first priority action as an intervention for scaling up global upcycling businesses should be 'involving citizens in upcycling initiatives and events for awareness raising including campaign, communication, training and education' (Levels 2 and 3 in ISM model for global opportunities) in order to

address 'consumers' low awareness of upcycling' and 'consumers' negative perception of upcycled products' (Levels 2 and 4 in ISM model for global challenges). The second priority interventions could be 'improving material provision' (Level 2 in Figure 4) and addressing 'time-consuming processes' (Level 3 in Figure 2) by 'suitable technologies, techniques, and innovation in production' (Level 1 in Figure 4).

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