A Stakeholder-based Assessment Model (SAM) for resource-efficiency measures in the construction industry

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Agenda

- Motivation and research question
- Research approach
- Stakeholder-based Assessment Model (SAM)
- Outlook
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**Motivation and research question**

Research question: What are the most effective political measures to incentivize the relevant stakeholders to reduce their resource consumption or increase the share of recyclables and recycling materials in their current practice?

**Material Flow Model**
- Input
- Output
- Political measures

**Stakeholder Model**
- Hiete, M. et al. (2011)
- Gruhler, K., Böhm, R. (2011)
- Deilmann, C., et al. (2017)

**Linked Model**
- Stock
- Conversion Renovation Aging
- Demolition & Recycling
- Building Materials

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Research approach

Goals:
- Reduce of the usage of primary raw materials by:
  - Higher usage of recycled raw materials as substitutes for primary resources
  - Increase of reuse and recycling of construction materials

Approaches in the Stakholder-based Assessment model (SAM):
- Definition of the key Stakeholders
- Investigation of stakeholder’s characteristics regarding their objectives and their potential impact on resource saving
- Investigation regarding:
  - Influence of a stakeholder group on another stakeholder group
  - Present and future political resource saving measures
  - Effects of those measures on the environment and on the stakeholders

Challenges / Research sub questions:
- Many Stakeholders with different characteristics
  - Who are the key stakeholders?
  - What is their role in achieving the goal?
  - How strong is the influence of a stakeholder group on another group?
- Many resource efficiency measures
  - What are the most effective measures?

Development of SAM
Motivation and research question

Research approach

Stakeholder-based Assessment Model (SAM)

Outlook
Stakeholder-based Assessment Model (SAM) – Model Overview

Stakeholder $a_1...a_n$
- Objective function
- Readiness to act according to a measure $m_k$

Reduction of primary material used

Effectivity of the measure (defined as impact of a measure on the protection of resources)

Stakeholder Network
- Builders
- Landfill sites
- Construction planning
- Government
- Building Companies
- Public authorities
- Recycling Companies
- Building materials Industry

Influence

cultural measures $m_1...m_K$
Objective function of a stakeholder $a_i$

$$Z_{a_i} = g_{fin_{a_i}} * fin_{a_i} + g_{cust_{a_i}} * cust_{a_i} + g_{process_{a_i}} * process_{a_i} + g_{dev_{a_i}} * dev_{a_i} + g_{env_{a_i}} * env_{a_i}$$

$fin_{a_i} =$ financial success of stakeholder $a_i$,
$cust_{a_i} =$ customer satisfaction of $a_i$,
$process_{a_i} =$ success of process design of $a_i$,
$dev_{a_i} =$ development/Innovation success of $a_i$,
$env_{a_i} =$ success of environmentally responsible behavior of $a_i$,
$g_{factor} =$ weight of the variables and has to be defined for each Stakeholder (sum of all $g=1$)
SAM - Data generation

- 9 Expert Interviews (e.g. Construction Planning, Public authorities, Recycling Companies,..)
- using Likert-items to scale/quantify responses [1;5]

**e.g. question 6:**
Please evaluate the influence of your company on the business activity of the following stakeholders. [1;5]

**e.g. question 7:**
Please evaluate the influence of the following stakeholders on the business activity of your company. [1;5]
SAM - Calculation of the effectivity of a measure $m$

$\text{Eff}(m_k) = \frac{1}{n} \sum_{i=1}^{n} \frac{3(l_m \cdot r_{ai} \cdot B_{ai,m_k})}{250}$

$B_{ai,m_k} = \frac{\text{Inf}_{a_i} + 2 \cdot w_{mk,a_i} \cdot s_{mk}}{3} \quad \forall k = 1, \ldots K$

$\text{Inf}_{a_i} = \frac{\sum_{i,j=1}^{n} (E_{ai,a_j}(m_k))}{\frac{1}{n} \sum_{i,j=1}^{n} (e_{ai,a_j})}$

$E_{ai,a_j}(m_k) = w_{mk,a_i} \cdot s_{mk} \cdot e_{ai,a_j}$

$w_{mk,a_i} = g_{\text{fin}_{ai}} \cdot w_{mk,\text{fin}_{ai}} + g_{\text{cust}_{ai}} \cdot w_{mk,\text{cust}_{ai}} + g_{\text{process}_{ai}} \cdot w_{mk,\text{process}_{ai}} + g_{\text{dev}_{ai}} \cdot w_{mk,\text{dev}_{ai}} + g_{\text{env}_{ai}} \cdot w_{mk,\text{env}_{ai}}$

$\text{Eff}(m_k) = \text{Effectivity of the measure } m_k,$

$l_{mk} = \text{Impact of the measure } m_k \text{ on the conservation of resources},$

$r_{ai} = \text{Influence of stakeholder } a_i \text{ on the conservation of resources},$

$B_{ai,m_k} = \text{Readiness to act of stakeholder } a_i \text{ while realizing measure } m_k,$

$\text{Inf}_{a_i} = \text{Additional readiness to act / acceptance of stakeholder } a_i,$

$E_{ai,a_j}(m_k) = \text{Influence of stakeholder } a_i \text{ on stakeholder } a_j \text{ in dependence of measure } m,$

$e_{ai,a_j} = \text{General level of influence of stakeholder } a_i \text{ on stakeholder } a_j$

$w_{mk,a_i} = \text{Impact (Imp.) of measure } m_k \text{ on stakeholder } a_i,$

$w_{mk,\text{fin}_{ai}} = \text{Imp. of } m_k \text{ on financial success of } a_i,$

$w_{mk,\text{cust}_{ai}} = \text{Imp. of } m_k \text{ on customer satisfaction of } a_i,$

$w_{mk,\text{process}_{ai}} = \text{Imp. of } m_k \text{ on process design of } a_i,$

$w_{mk,\text{dev}_{ai}} = \text{Imp. of } m_k \text{ on development/innovation success of } a_i,$

$w_{mk,\text{env}_{ai}} = \text{Imp. of } m_k \text{ on environmentally responsible behaviour of } a_i$

Solved in Excel VBA
SAM - Conclusion

Highest readiness to act

Highest effectivity

Legend:

1. Development of incentive schemes
2. Reducing barriers for resource-efficient behaviour
3. Adoption of the construction cycle in sense of a circular economy
4. Environmentally responsible production of construction materials
5. Further development of low waste construction processes
6. Stronger awareness of resource-efficient construction
7. Further development of recycling techniques
8. Stronger investments for resource-efficient research
9. Higher information availability
10. Initiation of more maintenance measures
11. Adoption of internal calculation and planning processes on environmentally responsible behaviour
12. Development of cooperation between the stakeholders
13. Ensure environmentally responsible waste treatment
14. Resource saving building design
15. Importance of a high quality in construction to extend the life cycle of buildings
16. Ensure high quality of recycled construction materials
17. Resource saving use of construction materials
18. Improvement of the image of recycled construction materials
19. Model character of public authorities
20. Development of a system of penalties for non-compliance
21. Stricter set of regulations
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Next steps:
- Impact of SAM on Material Flows
- Impact of synergies between political measures on material flows
- Improvement of data, based on surveys (distributed through associations of the constr. industry)
Literature

Hiete, M. et al. (2011), Matching construction and demolition waste supply to recycling demand: a regional management chain model, Karlsruhe Institute of Technology (KIT), Building Research & Information 39(4), 333-351

Deilmann, C., Gruhler, K. (2005), Stoff- und Energieflüsse von Gebäuden und Infrastrukturen als Grundlage für ein vorausschauendes szenariogesteuertes Stoffstrommanagement,


Gruhler, K., Böhm, R. (2011), Auswirkungen des demografischen Wandels auf das Stofflager und die Stoffflüsse des Wohngebäudebestandes – Deutschland 2050 –, Leibniz-Institut für ökologische Raumentwicklung Dresden e.V.

Deilmann, C. et al. (2017), Materialströme im Hochbau – Potenziale für eine Kreislaufwirtschaft, Forschung für die Praxis Band 6


Literature


Thank you

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