



# Agriculture activity ontology as a basis of core vocabulary for farm management systems

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# Standardization of Agricultural Activities

## ■ Background

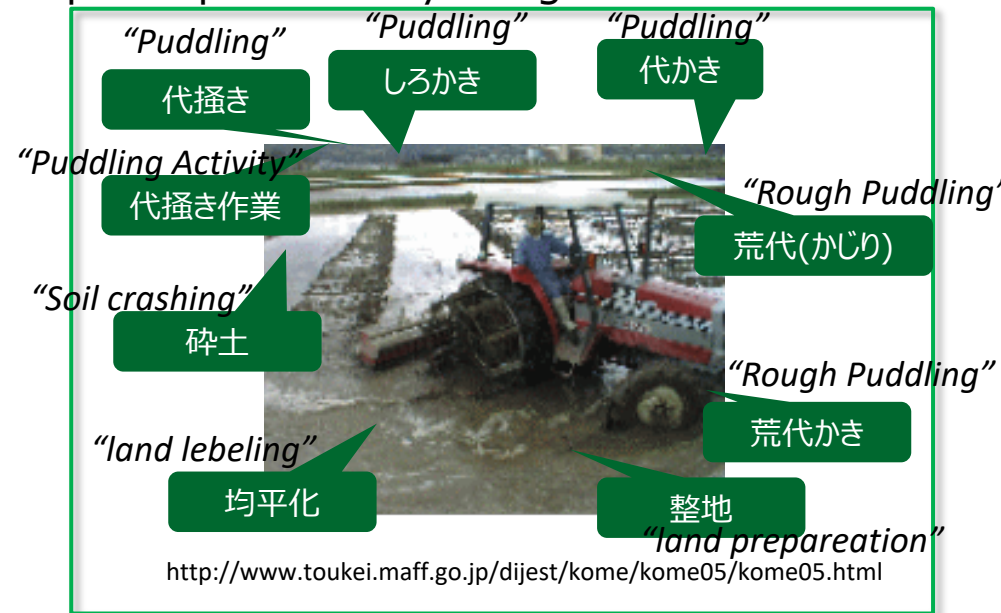
Agricultural IT systems are widely adopted to manage and record activities in the fields efficiently. Interoperability among these systems is needed to integrate and analyze such records to improve productivity of agriculture.

## ■ Issues

No standards are provided for names of works so that each system vendor defines them independently. It prevents federation and integration of these systems and their data.

## ■ Purpose

To provide the standard vocabulary by defining the ontology for agricultural activity



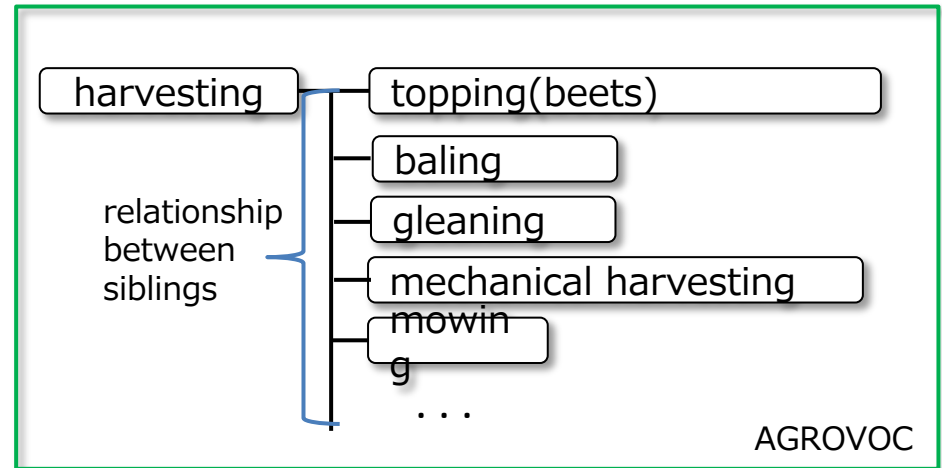
# Standardization of Agricultural Activities

## ■ Thesaurus

A system to organize **words** by synonym, narrower/broader, and related relationship. (ex. AGROVOC)

Search related words efficiently

- Narrower/broader relationship is not clearly defined. So relationship among both words are often mixed and misunderstood.



# Lessons learnt – What should be considered

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## ■ **Define hierarchy clearly**

Hierarchy is convenient for human to understand and for computers to process. But it often be confused by mixing different criteria on relationship among concepts/words. It causes difficulty when adding new concepts/words and when integrating different hierarchies.

- ➔ Define relationship clearly between upper and lower concepts as basis of classification

## ■ **Accept various synonymous words**

Names for a single concept may be multiple by region and by crop

- ➔ Clarify an entry word and their synonyms for each concept

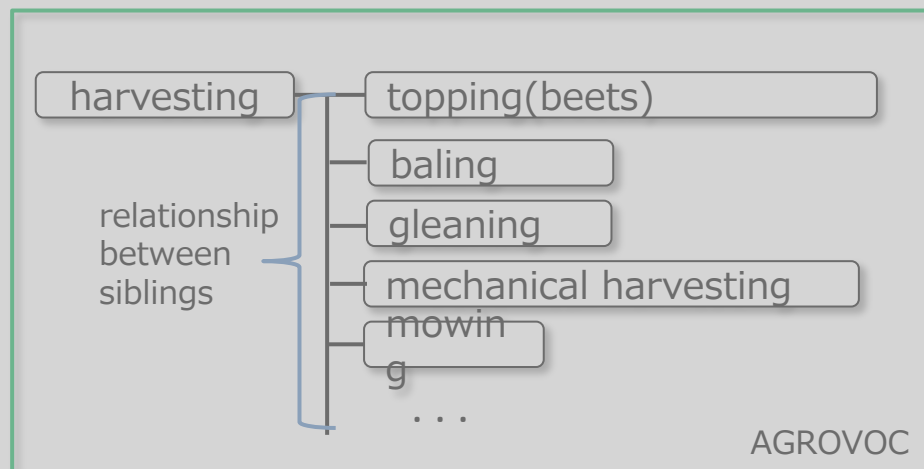
# Thesaurus and Ontology

## ■ Thesaurus

A system to organize **words** by synonym, narrower/broader, and related relationship. (ex. AGROVOC)

Search related words efficiently

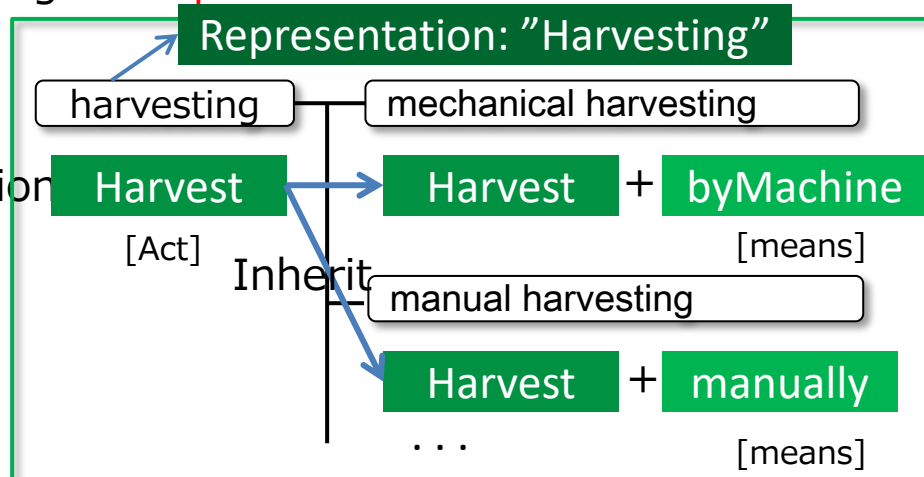
- Narrower/broader relationship is not clearly defined. So relationship among both words are often mixed and misunderstood.



## ■ Ontology

A system to define relationship among **concepts**

- Hierarchy by generalization/specialization relationship
  - Property inheritance
- Separate concept and representation



# Designing “Agricultural Activity Ontology”

The ontology to provide semantics for agricultural activity names

ver 1.10 : published on February 12, 2016. 330 words collected, new words are collected

ver 1.00 : published on November 2, 2015. 301 words collected, defined with Description Logics, introduction of property

ver 0.94 : published on May 12, 2015. 185 words collected.



The screenshot shows the homepage of the Common Agricultural Vocabulary (CAVOC). At the top left is the CAVOC logo, which consists of a stylized green and yellow circular emblem with the text "CAVOC" and "Common Agricultural Vocabulary" below it. Below the logo is a navigation bar with links: "お知らせ" (Information), "共通農業語彙(CAVOC)" (Common Agricultural Vocabulary), "研究グループ" (Research Group), "語彙検索" (Vocabulary Search), "語彙集(B)" (Vocabulary Collection B), and "リンク" (Link). The main content area features a search bar with the text "語彙検索:" and a search button. Below the search bar, there are several news items: "農作業基本オントロジー(ver 1.00)を公開しました。" (Agricultural Activity Ontology (ver 1.00) released), "農作業基本オントロジー(AAO: Agriculture Activity Ontology) ver 1.00を公開しました。" (Agricultural Activity Ontology (AAO: Agriculture Activity Ontology) ver 1.00 released), "農作業基本オントロジー(ver 0.94)を公開しました。" (Agricultural Activity Ontology (ver 0.94) released), and "研究発表: APAN 39th Conference" (Research Presentation: APAN 39th Conference). At the bottom right, there is a logo for "農研機構" (National Institute of Advanced Industrial Science and Technology) and "NII 国立情報学研究所" (National Institute of Informatics). The footer contains the URL "cavoc.org".

<http://www.cavoc.org/>



The screenshot shows the page for the Agricultural Activity Ontology (AAO) on the CAVOC website. At the top left is the CAVOC logo. Below it is the title "AAO : 農作業基本オントロジー(Agriculture Activity Ontology)". The main content area is a table with the following information:

ID	aao
NAME	農作業基本オントロジー (Agriculture Activity Ontology)
URL	<a href="http://www.cavoc.org/aao/ra/1/">http://www.cavoc.org/aao/ra/1/</a>
LATEST VERSION	1.10 (2016-02-12)

To the right of the table is a tree view of the ontology structure, showing a hierarchy of agricultural activities. The root is "作物生産作業" (Crop Production Work), which branches into "作物生育作業" (Crop Growth Work), "繁殖制御作業" (Reproduction Control Work), "農産物収穫作業" (Crop Harvesting Work), "栄養調整作業" (Nutrient Adjustment Work), "収穫後処理作業" (Post-harvest Processing Work), "肥料散布作業" (Fertilizer Spreading Work), "除草作業" (Weeding Work), "灌水作業" (Irrigation Work), "乾田管理" (Dry Field Management), "覆土" (Covering Soil), "作業" (Work), "挿し木" (Cuttings), "接ぎ木" (Grafting), "呼び寄せ" (Calling), "取り寄せ" (Ordering), "取り分け" (Ordering), "平切り" (Flattening), "分球" (Dividing), "発芽促進作業" (Germination Promotion Work), "催芽" (Germination), "浸種" (Soaking), "芒取り" (Straw Removal), "種子コーティング" (Seed Coating), "種コーティング" (Seed Coating), "種苗選別" (Seedling Selection), and "選種" (Seed Selection).

The footer contains the URL "cavoc.org".

<http://www.cavoc.org/aao>

# Designing Agricultural Activity Ontology

## ■ Define activity concepts



Activity for Seeding:  
activity to **sow seeds** on **fields** for **seed propagation**



“Activity for Seeding” is { Purpose: **seed propagation**  
Place : **field**  
Target : **seed**  
Act : **sow**



Define activities with  
properties and their values

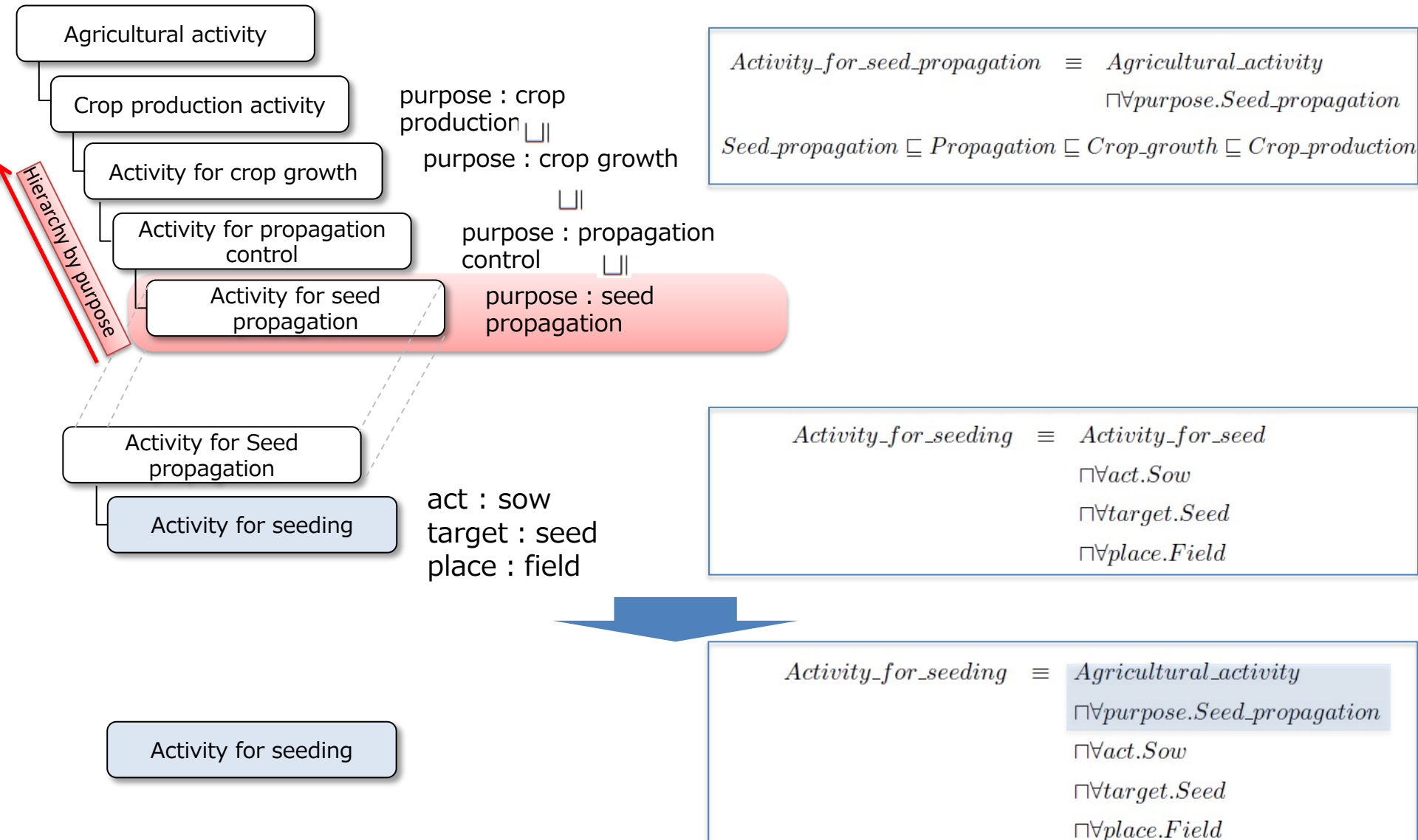
## ■ Define hierarchy

The hierarchy of activities is organized by property

- New properties and their values are added
  - “**purpose**”, “**act**”, “**target**”, “**place**”, “**means**”, “**season**”, and “**crop**” in order.
- Property values are specialized

# Designing Agricultural Activity Ontology

## Formalization by Description Logics





# Designing Agricultural Activity Ontology

## ■ Differentiate concepts by property

Agricultural activity  $\supset \dots \supset$  Activity for seed propagation  
purpose : seed propagation

$Activity\_for\_seeding \equiv Agricultural\_activity$   
 $\sqcap \forall purpose.Seed\_propagation$   
 $\sqcap \forall act.Sow$   
 $\sqcap \forall target.Seed$   
 $\sqcap \forall place.Field$

$Well\_drained\_paddy\_field \sqsubseteq Field$

$Paddy\_field \sqsubseteq Field$

$Direct\_sowing\_of\_rice\_on\_well\_drained\_paddy\_field \sqsubseteq Agricultural\_activity$   
 $\sqcap \forall purpose.Seed\_propagation$   
 $\sqcap \forall act.Sow$   
 $\sqcap \forall target.Seed$   
 $\sqcap \forall place.Well\_drained\_paddy\_field$   
 $\sqcap \forall crop.Rice$

$Direct\_seeding\_in\_flooded\_paddy\_field \sqsubseteq Agricultural\_activity$   
 $\sqcap \forall purpose.Seed\_propagation$   
 $\sqcap \forall act.Sow$   
 $\sqcap \forall target.Seed$   
 $\sqcap \forall place.Paddy\_field$   
 $\sqcap \forall crop.Rice$

# Designing Agricultural Activity Ontology

## Management by Protégé

The screenshot displays the Protégé ontology editor interface. On the left, a class hierarchy is shown under 'owl:Thing', with '作物生産作業' (Crop Production Activity) expanded to show sub-classes like 'モニタリング' (Monitoring), '作物生産支援作業' (Crop Production Support Activity), '作物生育作業' (Crop Growth Activity), and '繁殖制御作業' (Breeding Control Activity). The '作物生育作業' class is highlighted in green. The main area shows a network diagram of activities, with '作物生産作業' connected to '作物生育作業', which is further connected to '繁殖準備作業', '種子繁殖作業', '結実制御作業', '栄養成長制御作業', '生殖成長制御作業', '栄養繁殖作業', '発芽促進作業', '外観制御作業', 'は種', and '袋掛け'. The 'は種' activity is further connected to '乾田直播', '湛水直播', and '苗箱直播'. The '発芽促進作業' activity is connected to '種子コーティング', '玉吊り', '種苗選別', '芒取り', '催芽', '覆土', and 'は種'. The '種子繁殖作業' activity is connected to '種子コーティング', '玉吊り', '種苗選別', '芒取り', '催芽', '覆土', and 'は種'. The '結実制御作業' activity is connected to '芒取り', '催芽', '覆土', and 'は種'. The '栄養成長制御作業' activity is connected to '芒取り', '催芽', '覆土', and 'は種'. The '生殖成長制御作業' activity is connected to '芒取り', '催芽', '覆土', and 'は種'. The '栄養繁殖作業' activity is connected to '芒取り', '催芽', '覆土', and 'は種'. The '外観制御作業' activity is connected to '芒取り', '催芽', '覆土', and 'は種'. The 'は種' activity is connected to '乾田直播', '湛水直播', and '苗箱直播'. The '袋掛け' activity is connected to 'は種'.

Activity for seeding

Direct sowing of rice on well-drained paddy field

Direct seeding in flooded paddy field

Seeding on a nursery box

# Designing Agricultural Activity Ontology

## ■ Polysemic concepts

- Definition of agriculture activities with multiple purposes or other properties.

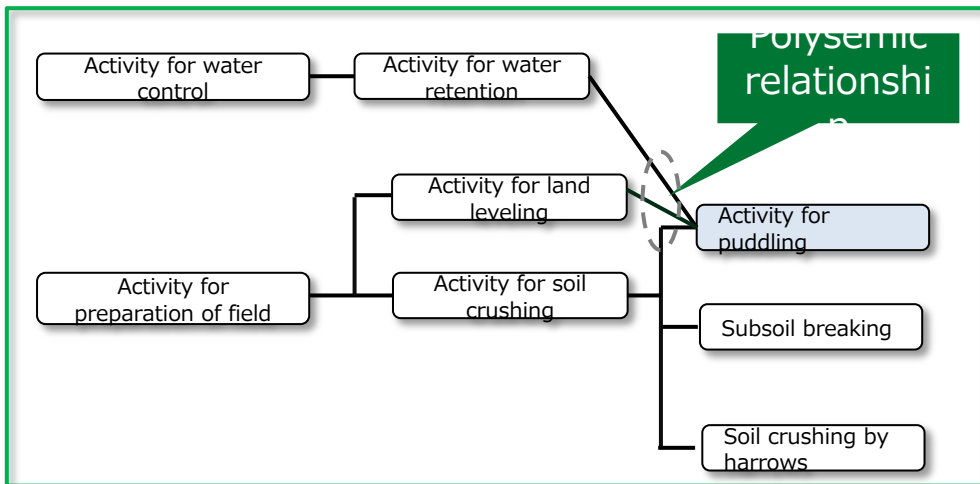
Activity for puddling



purpose : soil crushing  
 purpose : water retention  
 purpose : land leveling

$$\begin{aligned}
 \text{Activity\_for\_puddling} \equiv & (\text{Agricultural\_activity} \\
 & \sqcap \forall \text{purpose.} \text{Soil\_preparation\_of\_field} \\
 & \sqcap \forall \text{act.} \text{puddle} \\
 & \sqcap \forall \text{place.} \text{Paddy\_field}) \\
 \sqcup & (\text{Agricultural\_activity} \\
 & \sqcap \forall \text{purpose.} \text{Soil\_preparation\_of\_field} \\
 & \sqcap \forall \text{act.} \text{Level} \\
 & \sqcap \forall \text{place.} \text{Field}) \\
 \sqcup & (\text{Agricultural\_activity} \sqcap \forall \text{Purpose.} \text{Water\_retention})
 \end{aligned}$$

[disjunction form]

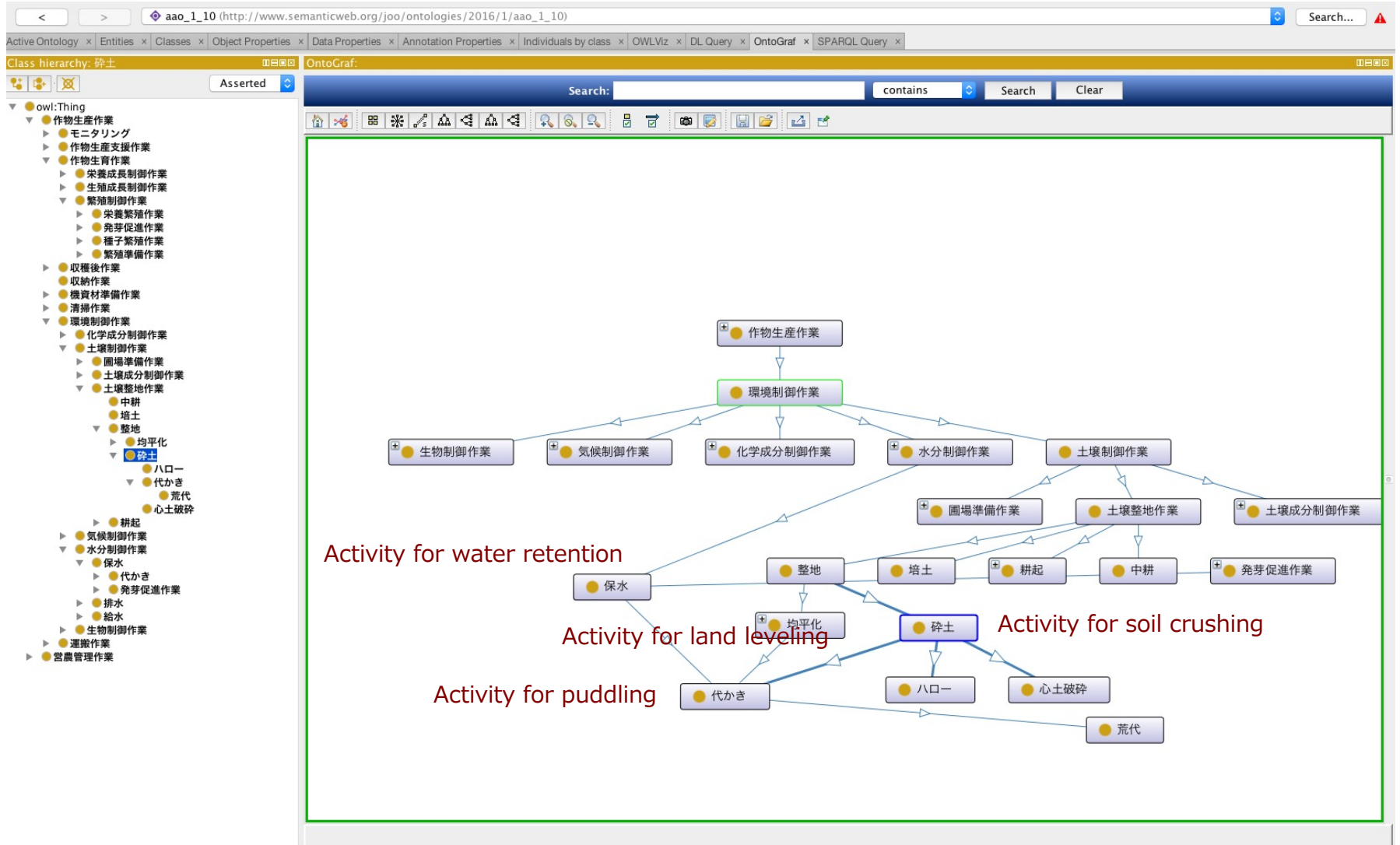


$$\begin{aligned}
 \text{Activity\_for\_puddling} \supseteq & \text{Agricultural\_activity} \\
 & \sqcap \forall \text{purpose.} (\text{Soil\_preparation\_of\_field} \sqcup \text{Water\_retention}) \\
 & \sqcap \forall \text{act.} (\text{Puddle} \sqcup \text{Level}) \\
 & \sqcap \forall \text{place.} \text{Paddy\_field}
 \end{aligned}$$

[conjunction form]

# Designing Agricultural Activity Ontology

## Management by Protégé - Polysemic concepts





# Applying Agricultural Activity Ontology

## ■ URI

Give a unique URI for each concept

<http://cavoc.org/aao/ns/1/は種>

PREFERRED TERM	<b>は種</b> はしゅ [Japanese hiragana] activity for seeding
BROADER CONCEPT	種子繁殖作業 Activity for seed propagation
NARROWER CONCEPT	苗箱播種 Seeding on a nursery box 湛水直播 Direct seeding in flooded paddy field 乾田直播 Direct sowing of rice on well-drained paddy field
ALTERNATIVE LABEL	播種 種まき [行為] 播く [act] sow [対象] 種 [target] seed
CAVOC Version	農作業基本オントロジー 1.10 (2016-02-12)

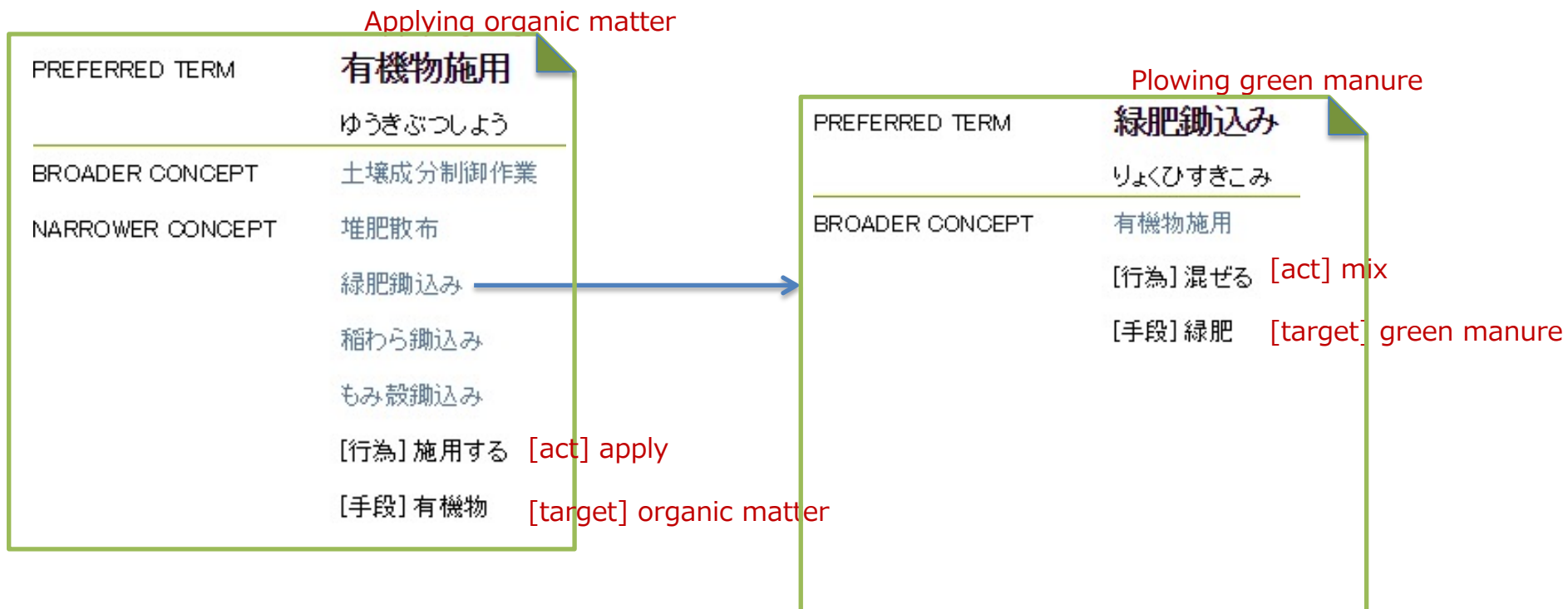
- 作物生産作業
  - 作物生育作業
    - 繁殖制御作業
      - 繁殖準備作業
        - 採種
        - 苗取り
      - 種子繁殖作業
        - は種
          - 苗箱播種
          - 湛水直播
          - 乾田直播
        - 覆土
      - 栄養繁殖作業
        - 挿し木
        - 接ぎ木
          - 呼び接ぎ
          - 割り接ぎ
        - 取り木
        - 株分け
          - 芋切り
        - 分球
      - 発芽促進作業

# Applying Agricultural Activity Ontology

## ■ Vocabulary Generation

Vocabulary is generated by processing the ontology. Vocabulary consists of terms, (non-terminological) concepts and properties.

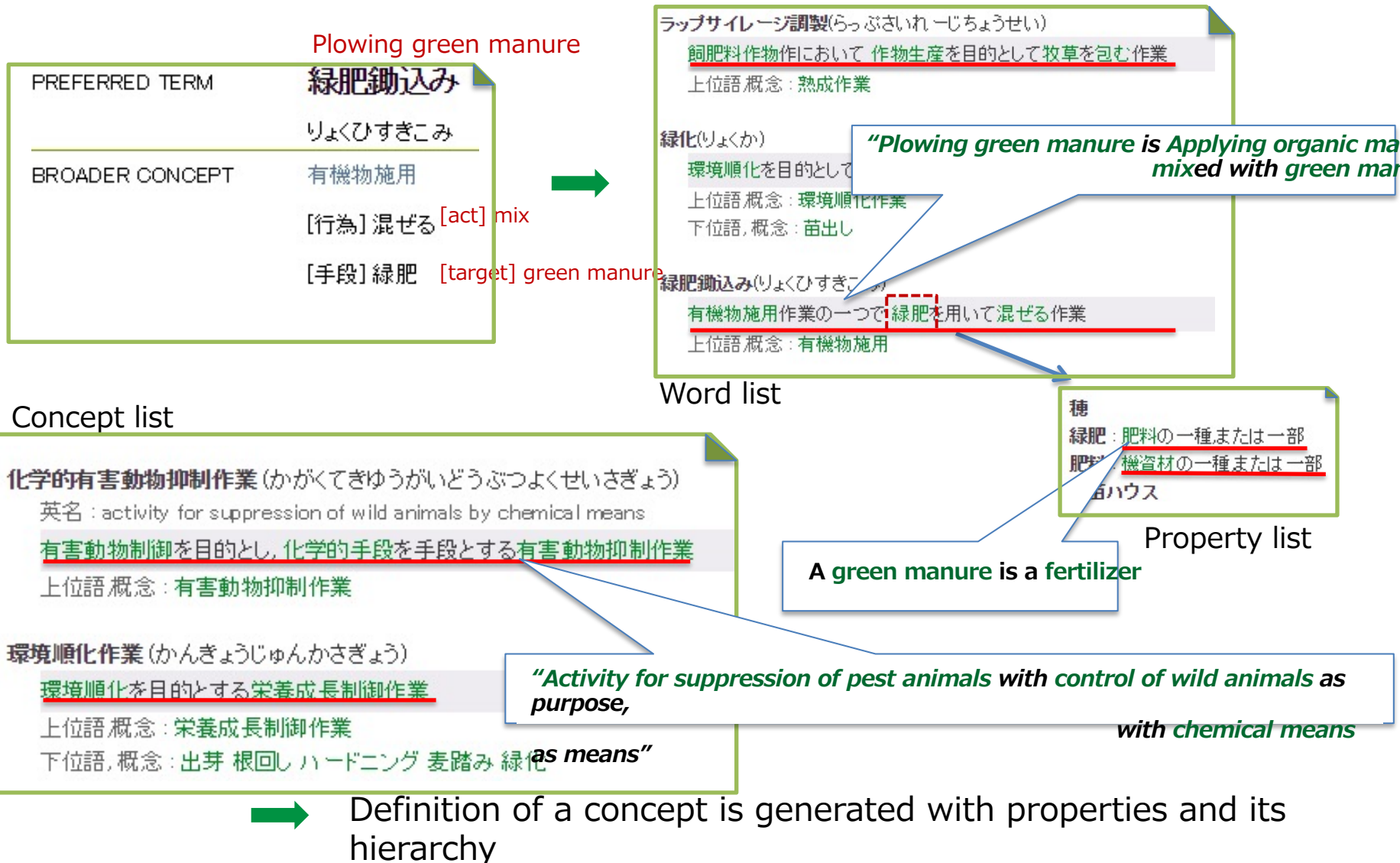
- Terms: Names of activities used by farmers, researchers, and so on.
- (Non-terminological) concepts: Concepts used to classify terms.
- Properties: Concepts used to define activity concepts.





# Applying Agricultural Activity Ontology

## ■ Generation of human-readable definition for terms and concepts





# Applying Agricultural Activity Ontology

## Reasoning by Ontology

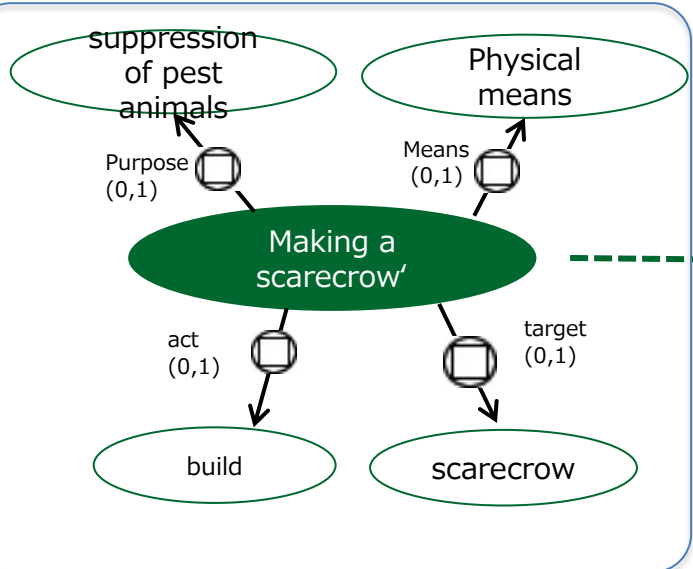
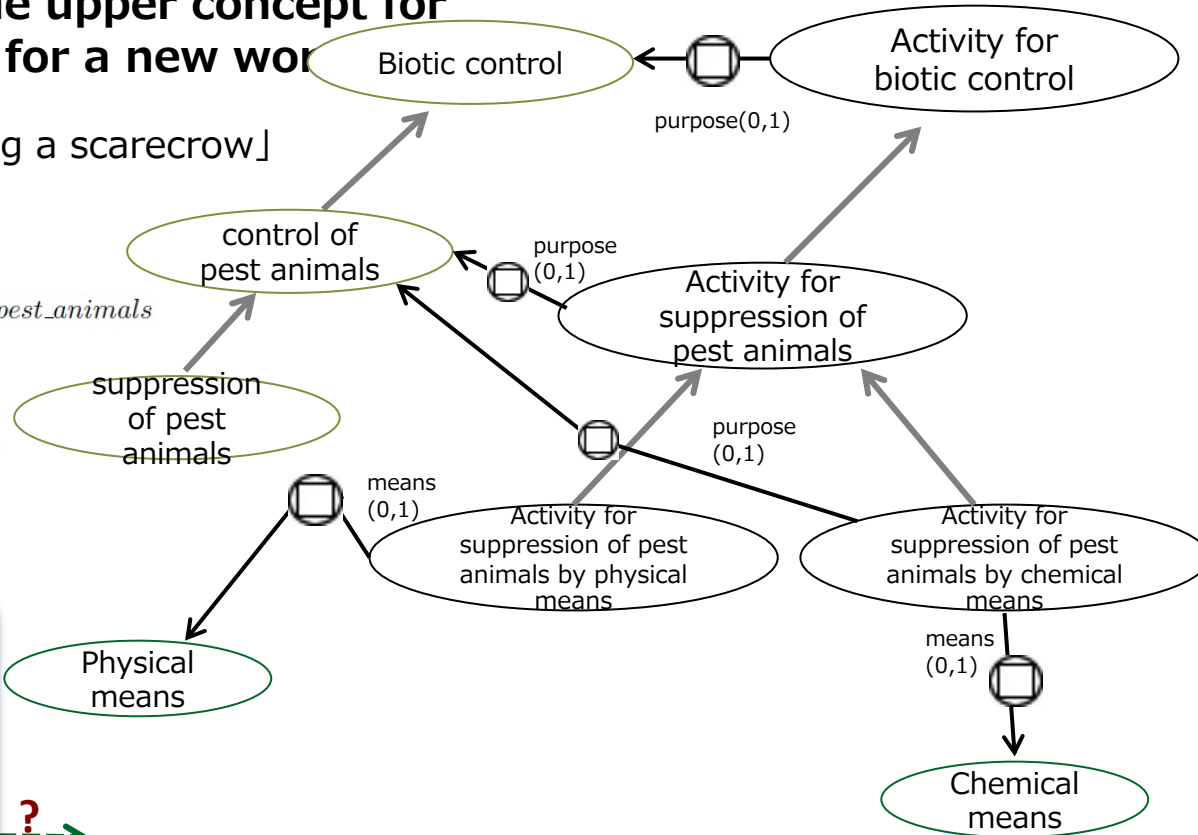
- Infer the most feasible upper concept for the given constraints for a new word



Example of [Making a scarecrow]

*Making\_a\_scarecrow'*

$\sqsupseteq \forall \text{purpose.} \text{Suppression\_of\_pest\_animals}$   
 $\sqcap \forall \text{act.} \text{Make}$   
 $\sqcap \forall \text{target.} \text{Scarecrow}$   
 $\sqcap \forall \text{means.} \text{Physical\_means}$



# Applying Agricultural Activity Ontology

## Reasoning by Ontology

[1] Seiji Koide, Theory and Implementation of Object Oriented Semantic Web Language, PhD Thesis, Graduate University for Advance Studies, 2011

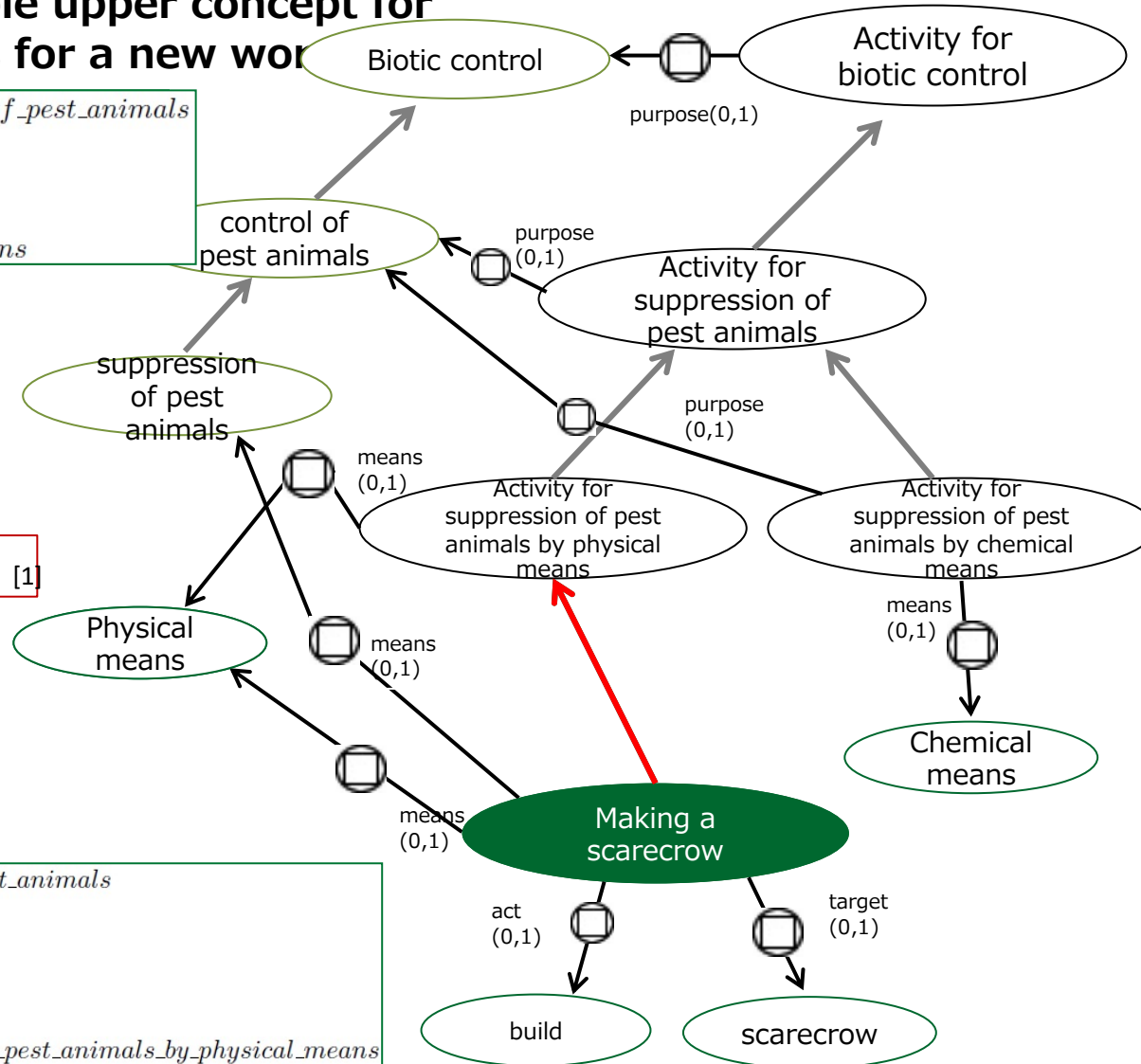
- Infer the most feasible upper concept for the given constraints for a new word

*Making\_a\_scarecrow'*  $\sqsubseteq$   $\forall$ purpose.*Suppression\_of\_pest\_animals*  
 $\sqcap$   $\forall$ act.*Make*  
 $\sqcap$   $\forall$ target.*Scarecrow*  
 $\sqcap$   $\forall$ means.*Physical\_means*

```

gx(9): (get-form cavoc.aao:かかし作り)
(owl:Class cavoc.aao:かかし作り
(rdfs:subClassOf
(owl:Restriction _:g1937
(owl:onProperty cavoc:目的)
(owl:allValuesFrom cavoc:有害動物抑制))
(owl:Restriction _:g1938
(owl:onProperty cavoc:行為)
(owl:allValuesFrom cavoc:作る))
(owl:Restriction _:g1939
(owl:onProperty cavoc:対象)
(owl:allValuesFrom cavoc:かかし))
(owl:Restriction _:g1940
(owl:onProperty cavoc:手段)
(owl:allValuesFrom cavoc:物理的手段)))
(rdfs:label "\かかし作り"@ja)
(cavoc:yomi "\かかしつくり"@ja))
gx(9): (refine-abstraction-from
cavoc.aao:作物生産作業
#<node cavoc.aao:物理的有害動物
gx(10): (get-form cavoc.aao:かかし作り)
(owl:Class cavoc.aao:かかし作り
(rdfs:subClassOf cavoc.aao:物理的有害動物抑制)
(owl:Restriction _:g1937
(owl:onProperty cavoc:目的)
(owl:allValuesFrom cavoc:有害動物抑制))
(owl:Restriction _:g1938
(owl:onProperty cavoc:行為)
(owl:allValuesFrom cavoc:作る))
(owl:Restriction _:g1939
(owl:onProperty cavoc:対象)
(owl:allValuesFrom cavoc:かかし))
(owl:Restriction _:g1940
(owl:onProperty cavoc:手段)
(owl:allValuesFrom cavoc:物理的手段)))
(rdfs:label "\かかし作り"@ja)
(cavoc:yomi "\かかしつくり"@ja))
    
```

Inference with SWCLOS



*Making\_a\_scarecrow*  $\sqsubseteq$   $\forall$ (purpose.*Suppression\_of\_pest\_animals*  
 $\sqcap$   $\forall$ act.*Make*  
 $\sqcap$   $\forall$ target.*Scarecrow*  
 $\sqcap$   $\forall$ means.*Physical\_means*)  
 $\sqcap$  *Activity\_for\_suppression\_of\_pest\_animals\_by\_physical\_means*

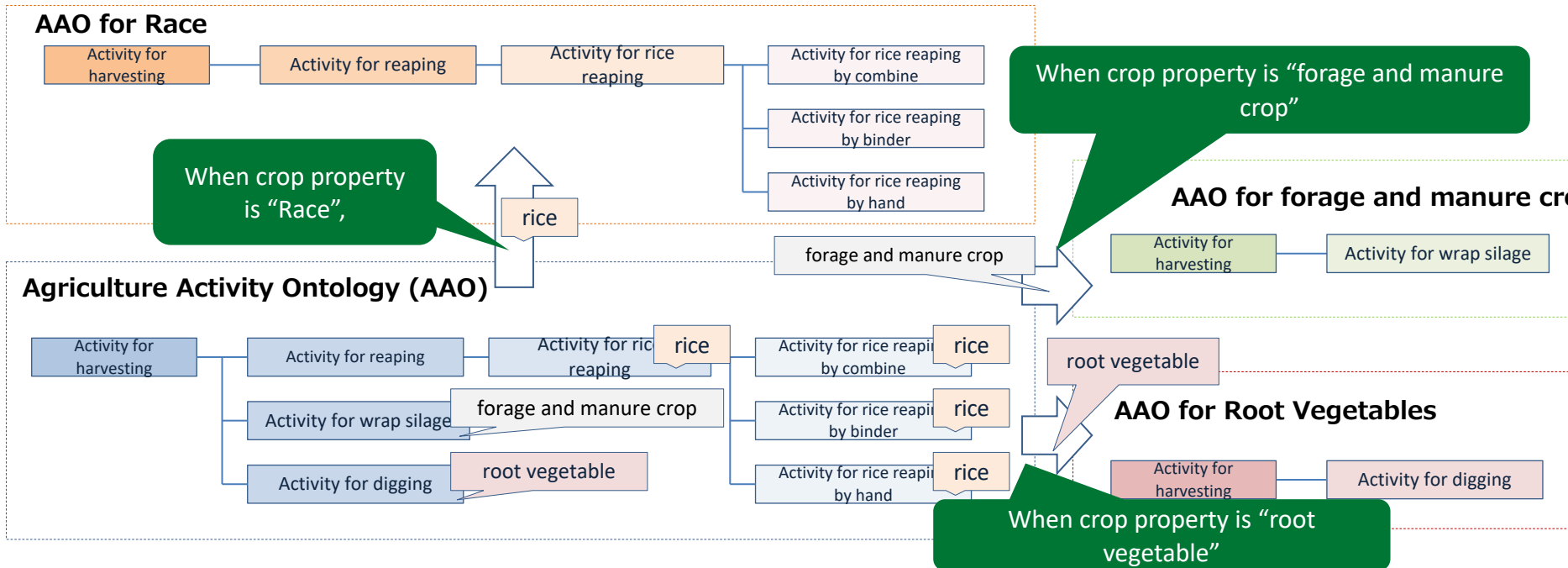
# Future work

## ■ Addition and verification of new words

Survey more documents and domains to collect words. By adding these words, properties and their values will be verified and extended if necessary.

## ■ Generation of crop-specific ontologies

AAO can generate crop-specific ontologies by specifying values of “crop” property. In order to complete these ontologies, concepts and properties may be added. Crop ontology should be provided too.



# Summary

- We proposed the ontology for agriculture activity and the vocabulary based on it in order to increase interoperability among agriculture management systems.
- The ontology provides clear definition for concepts and hierarchy among concepts, separation between names and concepts, and functions to define complex concepts.
- The ontology is defined with Description Logics so that logical inference is provided.
- Future work includes addition and verification of new words, generation of crop-specific ontologies.
- We will further apply our approach to crop, fertilizer, and agricultural chemicals to extend the vocabulary.

Common Agricultural VOCabulary

<http://cavoc.org/>

Agriculture Activity Ontology (AAO) ver 1.10

<http://cavoc.org/aao/>



お知らせ | 共通農業語彙(CAVOC) | 研究グループ | 語彙検索 | リンク

▶ 農業基本オントロジー(ver 0.94)を公開しました。

農業基本オントロジー(AAO - Agriculture Activity Ontology) ver 0.94を公開しました。

<http://cavoc.org/aao/>

[2015/5/12]

▶ 研究発表 | APAN 39th Conference [2015/3/4]

▶ AGROVOC SPARQL Endpoint [2015/1/22]



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