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PURE

Pesticide Use-and-risk Reduction in European farming systems with Integrated Pest Management

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Collaborative Project
SEVENTH FRAMEWORK PROGRAMME

D1.7
Final versions of DEXiPM assessment tool

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Concerned workpackage leader: Jean-Noël Aubertot
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Dissemination Level	
PU Public	**PU**
PP Restricted to other programme participants (including the Commission Services)	
RE Restricted to a group specified by the consortium (including the Commission Services)	
CO Confidential, only for members of the consortium (including the Commission Services)	

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1. Summary

Task 1.2 of the PURE research project was in charge of adapting and further improving DEXiPM, a pivotal multi-criteria assessment tool of PURE, for its use in WP2 to 7 for *ex ant*e and *ex post* assessment of IPM solutions. Final versions of the diverse versions of DEXiPM can be provided on demand with also:

- ✓ Files helping in collecting model input data
- ✓ License agreements under the European agency for programme protection
- ✓ Agreement for model transfer to PURE partners.

2. Objectives

DEXiPM (Pelzer et al. 2012)[1] is a hierarchical qualitative multi-criteria model supported by the software DEXi[2]. The original version of DEXiPM has been designed and tested for arable cropping systems assessment by the ENDURE Network of Excellence. The model evaluates the overall sustainability of a cropping system by decomposing it into nested specific attributes that characterise environmental, social and economic sustainability. The model's attributes are characterised by qualitative classes of values and their aggregation into more complex attributes is defined by utility functions (set of if-then rules). Those functions are synthesised by relative weights which are affected to the involved attributes, reflecting their influence on the value of the upper one. The basic attributes of the tree represent the model's inputs and they are related to the cropping system (object of the assessment), as well as the production situation.

This tool has been chosen as central model within the PURE research project. For each chosen key European farming system (arable, field vegetables, protected vegetables, grapevine and pomefruit), a group of researchers and advisers designs prototypes of cropping systems with the objective of reducing pesticide use. Their performances are assessed with models and compared to the ones of currently widespread systems, before their test in field (*ex ante*). In this way, it is possible to adjust/improve the prototypes that are then implemented on experimental stations and commercial farms. After a test in the field, another assessment (*ex post*) is carried out and the results are exploited. These results may be used as an input for developing new knowledge and tools for IPM, as well as for adjusting the prototypes to be tested in the field.

In this framework, specific versions of DEXiPM for field and protected vegetables, grapevine and pomefruit orchards have been derived and represented the basis for assessing *ex ante* and *ex post* the performances of different cropping systems (current and IPM) for each of the farming systems involved in PURE.

3. Results

Several models were designed or improved during the PURE project. The following versions and files can be provided on demand (and with licences agreements) for research purposes.

<u>DEXiPM for *ex ante* assessment</u>

- **Arable crops**: new version with improved biodiversity branch (.dxi) and help file for collecting input data;
- **Field vegetables:** model description, model (.dxi) and help file for collecting input data;
- **Grapevine:** model (.dxi) and help file for collecting input data;
- **Protected vegetables:** model (.dxi).

[1] Pelzer, E., Fortino, G., Bockstaller, C., Angevin, F., Lamine, C., Moonen, C., Vasileiadis, V., Guérin, D., Guichard, L., Reau, R., Messéan, A., 2012. Assessing innovative cropping systems with DEXiPM, a qualitative multi-criteria assessment tool derived from DEXi. *Ecological indicators*, 18, 171-182.

[2] DEXi: A Program for Multi-Attribute Decision Making (http://www-ai.ijs.si/MarkoBohanec/dexi.html)

The DEXiPM-pomefruit model for *ex ante* assessment was designed during the French research project Altcarpo and was not modified during the PURE project.

DEXiPM for *ex post* assessment:

According to available data and the possibility to use output results of other models, such as Synops, several models have been developed during the project (See Annexes I & II for details). As previously mentioned, these models and files are available on demand and with license agreements.

- **Arable crops:** models and help file for collecting input data;
- **Field vegetables:** models and help file for collecting input data;
- **Pomefruits**: models and help file for collecting input data, related deliverable (D5.2).

Access to the different versions of DEXiPM© for research applications is governed by a license agreement (see annex III) under the European agency for programme protection (http://www.app.asso.fr/en/welcome.html) granted to INRA in 2009 (Arable crops) and in 2013 (Field vegetables, pomefruit and grapevine). This helps to protect INRA in the case of liability issues.

Members of the PURE consortium could have access to these models if they sign a licence agreement (see Annex III). The use is restricted to research purposes.

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4. ANNEX I: DEXiPM *ex post* assessment guidelines

This document is included in the "DEXiPM *ex post* assessment package" of your PURE WP (2-7) and illustrates the approach that should be adopted for using the model in an *ex post* frame; namely how (i) the model can be modified, (ii) quantitative thresholds have to be fixed for the new inputs and (iii) data entering.

Model modifications

In the *ex post* frame the use of measurements instead of expertise can sensibly improve the assessment reliability. Nevertheless, it is usually difficult to measure a wide set of indicators, thus some of them can be estimated via quantitative models. DEXiPM being originally designed for exploiting qualitative information on practices and context, its optimal use in an *ex post* frame implies some adaptations according to the available data. The first step is the identification of the indicators that can be measured or quantitatively estimated with models. The second step is their inclusion in DEXiPM by "pruning" the model structure[3]. This process consists of the removal of the basic hierarchical levels of the model used for the qualitative estimation of an attribute that are no longer needed in ex post because of its direct availability.

The model can be modified as follows:

1. In the "model" tab of DEXi, the aggregated attribute that is measured or estimated with field records has to be selected and the "delete" command has to be chosen on the toolbar in the middle of the window (or under the Edit menu, Figure 1).
2. In this way the aggregated attribute is transformed into a basic one (deletion of descendants and change in icon shape).
3. By clicking on the "duplicate" command a copy of the attribute is stored at the bottom of the inputs list of the model (Figure 2).
4. As a consequence, it will be easily found at the bottom of the "options" tab list (Figure 3).

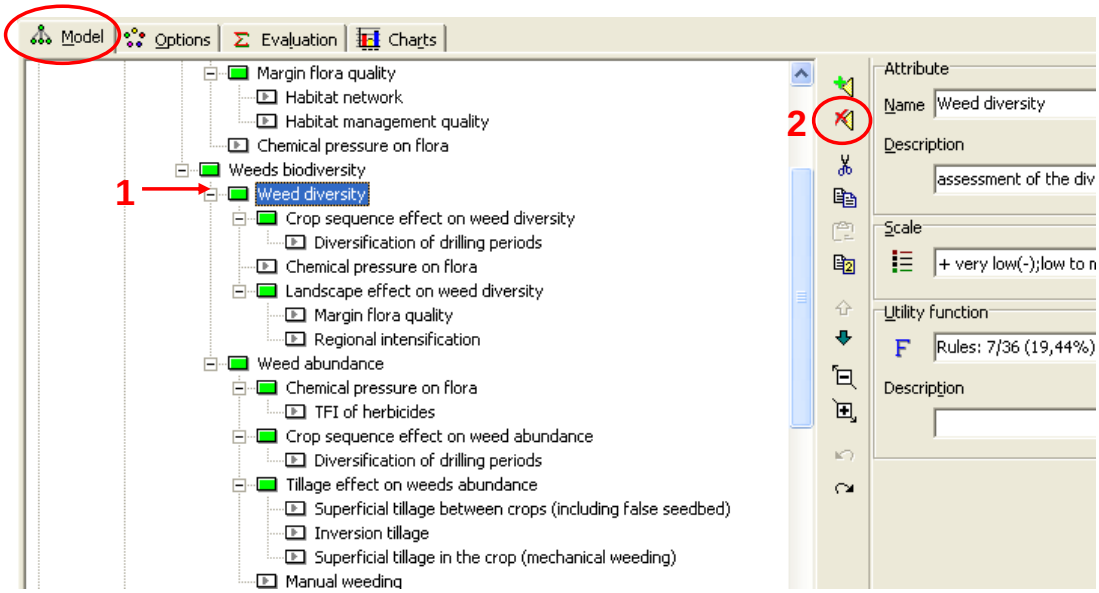

Figure 1. Screenshot of DEXIPM© under DEXi. Example of a pruning action (steps 1 and 2).

[3] Because of the methodological differences between DEXiPM and Synops, the pesticide risk indicators have been included in the model following a more complex procedure; the specific modifications brought are illustrated in annex.

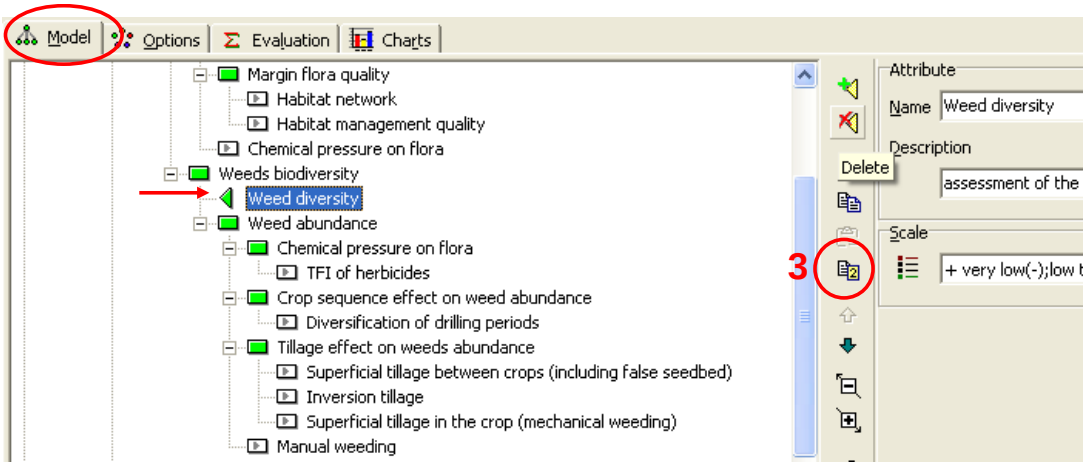

Figure 2. Screenshot of DEXIPM© under DEXi. Example of a duplication of a sub-tree (step 3).

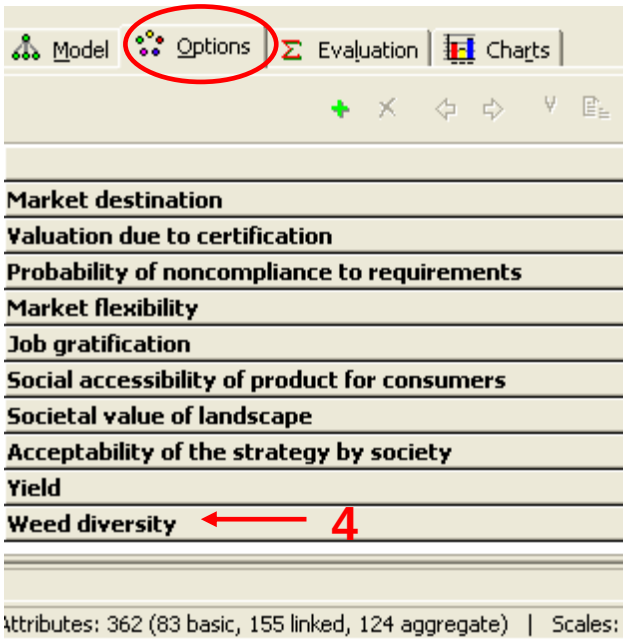

Figure 3. Screenshot of DEXIPM© under DEXi. Example of a duplication of a sub-tree (step 4). The selected attribute is now listed as an input attribute in the "options" menu.

The *ex post* assessment package contains different version of DEXiPM accompanied by a corresponding excel file. These files have the same structure as those used for the *ex ante* assessment; the difference between them is the modifications in structure and the relative information required for running the assessment.
In this package, we have considered some standard modifications that are expected to be needed in each WP according to the description of the *ex post* assessment tasks in the PURE DOW. As a result, we have proposed five standard DEXiPM *ex post* versions for each WP:

- Level 0: The « production risk » is deleted as well as the distinction between real and potential profitability[4].
- Level 1: level 0 + « yield » becomes a model input.
- Level 2a: level 1 + cost-benefit analysis outcomes exploited as DEXiPM inputs (i.e. "gross margin", "production value", "cost of pesticides").
- Level 2b: level 1 + Synops[5] outcomes exploited as DEXiPM inputs (e.g. chronic risk for "aquatic organisms").
- Level 3: level 2a + level 2b.

The choice of the version to be used by each WP (or WP member) is done according to the available quantitative data.

Beside these standard versions, other indicators can be estimated from field records and can be integrated as DEXiPM inputs. For example, weeds diversity and abundance, flying natural enemies, energy consumption.

New quantitative thresholds

The indicators estimated with quantitative assessment methods are then used as DEXiPM inputs, which are characterised by qualitative classes (e.g. *high/medium/low*). In order to support the translation of the quantitative value into the qualitative class, thresholds have to be defined. The way thresholds are set depends on the indicator nature.

Yield

Besides the cropping system management strategy and year-specific bioclimatic conditions, crop yield is influenced by relatively stable local pedoclimatic conditions. For this reason yield thresholds have to be fixed according to local knowledge (e.g. regional surveys).
Considering that this attribute is estimated at the crop rotation scale, a single set of thresholds is meaningless; as a consequence, a specific method has been defined for choosing the qualitative yield value corresponding to a cropping system.

Qualitative class	**Yield range (tons ha^{-1})**	*Standard coefficient*
very low	[0-4]	*1*
low	]4-6]	*2*
medium	]6-8]	*3*
high	]8-10]	*4*
very high	>10	*5*

Table 1 –Thresholds set for the qualitative « yield » attribute for wheat crop in the Parisian Basin

A preliminary step is the allocation of a standard coefficient to the five classes of the attribute (i.e. *very low* = 1, *low* = 2, etc.). Then, according to local surveys data, quantitative yield thresholds are defined for each crop of the rotation (see the example in table 1). Once quantitative values are available from field records, they are related with the corresponding standard coefficient according to the thresholds. Then, the average at the crop rotation scale is

[4] not all the WPs are concerned by this modification
[5] Strassemeyer J., Golla B., Daehmlow D., Horney P., Gutsche V. (2013). SYNOPS-WEB, an easy-to-use online tool to assess the potential aquatic and terrestrial risk of pesticides on field level. In: Future IPM in Europe - 19-21 March 2013 – Palazzo Congressi, Riva del Garda, Italy, p. 216.

calculated and the result is related to the corresponding qualitative class. For example, a four-year long rotation characterised by one crop with *medium* yield (numeric coefficient = 3), two with *high* (4) and one with *very high* (5), will result in the average value of 4 which corresponds to the class *high*.

Economic indicators
Yield has a strong influence on economic indicators; moreover the structure of production chains can also vary from a context to another, determining relevant variations in economic performances. For these reasons, economic indicators should also be fixed according to local knowledge.

When local survey data are not available and/or not all the variables needed for estimating an economic indicators are measured (i.e. partial cost-benefit analysis), it is possible to use relative thresholds. With this method, the value obtained for the Current System is set as the reference value and associated by default to a qualitative class (generally the *medium* one), while the thresholds are set relatively to this value (see example in Table 2).

Qualitative class	**Range**
very low	Less than -30% reference
low	between -10 % and - 30% reference
medium	between -10 % and +10% reference
high	between +10 % and +30% reference
very high	More than +30% reference

Table 2 – Example of relative thresholds set

Because of the relevance of the *medium* class for these indicators, the number of classes of gross margin, production value and cost of pesticides has been increased from four to five. As a consequence, the utility functions involving these attributes have been adapted.

Synops indicators
Regarding the Exposure Toxicity Ratios, the threshold used are the same than those used for analysing Synops results (see table 3 below).

Qualitative class	**Acute ETR range**	**Chronic ETR range**
Very low	[0-0.01]	[0-0.1]
Low	]0.01-0.1]	]0.1-1]
Medium	]0.1-1]	]1-10]
High	> 1	> 10

Table 3 – Thresholds for Exposure Toxicity Ratios

Regarding the pesticide Leaching Risk Indicators, we have split in two the two classes used in Synops in order to better discriminating the values (see table 4 below).

Qualitative class	**LRI range**
Very low	[0-0.1]
Low to medium	]0.1-1]
Medium to high	]1-10]
Very high	> 10

Table 4 – Thresholds for Leaching Risk Indicators

Other indicators
Thresholds for other indicators such as weeds diversity or flying natural enemies should be fixed on the basis of expert knowledge.

Data entering
Data entering is done as for the *ex ante* assessment; the only difference is in the list of inputs. As previously described, model modifications have determined the addition of quantitative inputs and the deletion of qualitative ones. In some cases, the deletion of the descendants of an aggregated attribute does not imply the complete removal of an input, because this is exploited in other parts of the model (e.g. TFI).

Hint: as the tested systems have already been described for the *ex ante* assessment, the user can use these data, checking if discrepancies between the cropping system prototype and the one implemented in field have been observed and data have to be modified.

5. ANNEX II: DEXiPM adaptations for use of Synops indicators (in collaboration with Jörn Strassemayer, JKI)

The integration in DEXiPM of the pesticide risk indicators calculated with the Synops model[6] has needed some structural adaptations. Indeed, these indicators do not exactly match with the existing qualitative attributes.

The first difference regards the distinction between acute and chronic risk present in Synops and not considered in DEXiPM. In order to include both indicators as DEXiPM inputs, a utility function has been created for their aggregation. The corresponding rules led to a relative weight of 40% for the acute and 60% for the chronic risk. These unbalance weights are justified by the fact that the acute risk indicator is determined by one active ingredient (worst-case), while the chronic risk indicator accounts for all the active ingredients applied during a growing season. The same argument has been used in SustainOS assessment tool[7].

The second difference is linked to the time scale of the assessment. Indeed, Synops indicators are calculated each year for each crop of the sequence, while the DEXiPM assessment is multiannual. At this scale, using only the maximum value (worst-case) the information about low risk years or crops would have not been accounted for, while using the average value the information on the high risk years or crops would be lost. In the end, it has been decided to include both values as inputs for DEXiPM aggregating them with a specific utility function where the "average risk" class is taken as reference and modulated by the "maximum risk" one (see figure below).

	AVG Pesticide chronic risk	MAX Pesticide chronic risk	**Pesticide chronic risk**
1	high: ETR>10	high: ETR>10	**very high**
2	high: ETR>10	medium: 1<ETR<10	*
3	high: ETR>10	low: 0.1<ETR<1	*
4	high: ETR>10	very low: ETR<0.1	*
5	medium: 1<ETR<10	high: ETR>10	**very high**
6	medium: 1<ETR<10	medium: 1<ETR<10	**high to medium**
7	medium: 1<ETR<10	low: 0.1<ETR<1	**medium to low**
8	medium: 1<ETR<10	very low: ETR<0.1	*
9	low: 0.1<ETR<1	high: ETR>10	**high to medium**
10	low: 0.1<ETR<1	medium: 1<ETR<10	**medium to low**
11	low: 0.1<ETR<1	low: 0.1<ETR<1	**very low**
12	low: 0.1<ETR<1	very low: ETR<0.1	*
13	very low: ETR<0.1	high: ETR>10	*
14	very low: ETR<0.1	medium: 1<ETR<10	**medium to low**
15	very low: ETR<0.1	low: 0.1<ETR<1	**very low**
16	very low: ETR<0.1	very low: ETR<0.1	**very low**

Figure 4. Utility function for the Pesticide chronic risk.

[6] Strassemeyer J., Golla B., Daehmlow D., Horney P., Gutsche V. (2013). SYNOPS-WEB, an easy-to-use online tool to assess the potential aquatic and terrestrial risk of pesticides on field level. In: Future IPM in Europe - 19-21 March 2013 – Palazzo Congressi, Riva del Garda, Italy, p. 216.

[7] Mouron P., Heijne B., Naef A., Strassemeyer J., Hayer F., Avilla J., Alaphilippe A., Höhn H., Hernandez J., Mack G., Gaillard G., Solé J., Sauphanor B., Patocchi A., Samietz J., Bravin E., Lavigne C., Bohanec M., Golla B., Scheer C., Aubert U., Bigler F. (2012) Sustainability assessment of crop protection systems: SustainOS methodology and its application for apple orchards. *Agricultural Systems* 113:1-15.

Other differences between Synops and DEXiPM indicators that have determined additional modifications are linked to the specific risk evaluated by the quantitative model. In this case, minor structural modifications have been brought to DEXiPM in order to integrate them (see table 5).

DEXiPM sub-tree	Synops specificity	DEXiPM complement
Aquatic eco-toxicity (Water quality)	Pesticide risk	Heavy metal risk
Chemical disturbances (Soil biological quality)	Pesticide risk for earthworms	Pesticide risk for other soil organisms
Chemical pressure on fauna (Aerial biodiversity)	Pesticide risk for bees	Pesticide risk for natural enemies

Table 5. Similarities and specificities of Synops and the DEXiPM sub-tree that represents ecotoxicological risks

For example, the integration of the specific pesticide risk for aquatic organisms assessed with Synops has been completed by the existing DEXiPM indicator accounting for heavy metals risk in the aquatic ecotoxicity module of DEXiPM (see Figure 4).

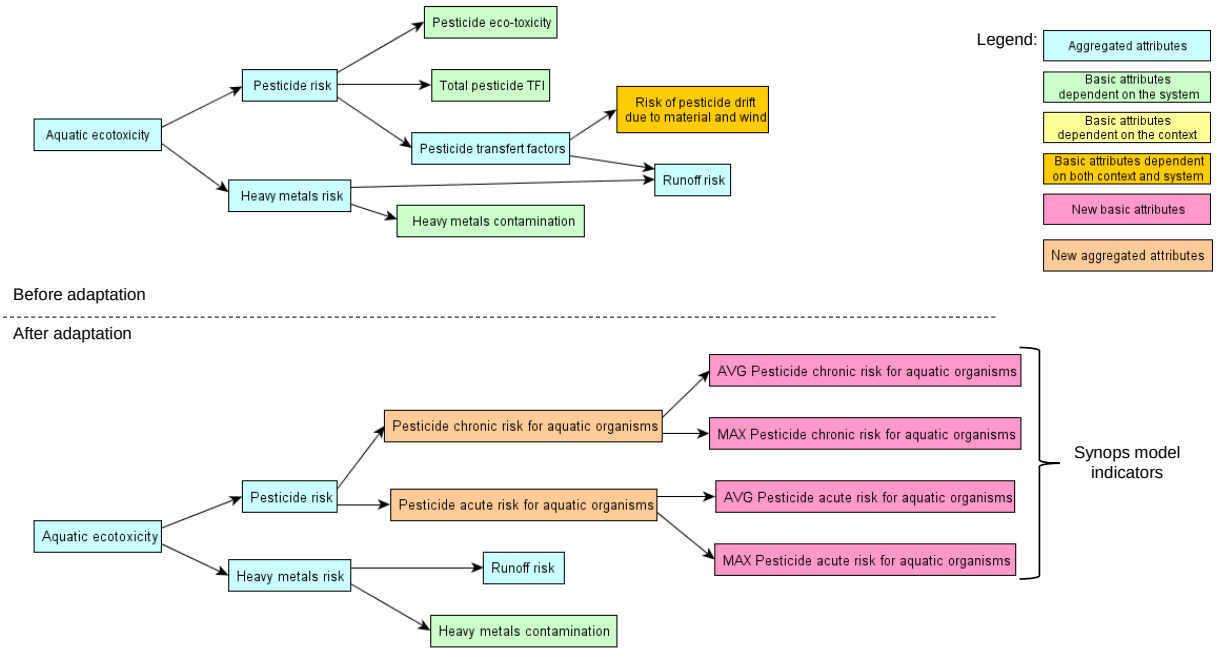

Figure 4. Adaptation of the aquatic ecotoxicity sub-tree in DEXiPM.

6. ANNEX III

MATERIAL TRANSFER AGREEMENT

BETWEEN:

INSTITUT NATIONAL DE LA RECHERCHE AGRONOMIQUE, a Public Research body dedicated to science and technology, hereinafter called "INRA', whose registered offices are located at 147, rue de l'Université, 75338 PARIS CEDEX 07, France, represented by Mr. François HOUILLER CEO, and by delegation by Mr. xxxxxx, Director of the Unit xxxxxx,
AND

YYYY (*the "Beneficiary"*), a [public/private entity] …, hereinafter called "the Beneficiary" whose registered offices are located at …, represented herein by …,

Individually called "the Party" or collectively "the Parties".

Whereas, the Parties hereto desire to exchange material and information thereof, based on the terms and conditions hereunder (hereafter referred to as "Agreement").

BEING UNDERSTOOD THAT

- XXX, as a Party to the FP7 "PURE" project, has in its possession material identified as DEXI-PM, the "MATERIAL", consisting of

  Include short description of DEXi-PM

  This MATERIAL and its transfer are subject to the compliance with intellectual property conditions settled in the FP7 "PURE" consortium agreement, which was signed on…./…./20..:

  The MATERIAL is also subject to the compliance with the use and access conditions applying to DEXI, which was developed by Dr Marko Bohanec and which consists in:

  Include short description of DEXi

- The Beneficiary is interested in the MATERIAL held by XXX to conduct non commercial tests and experiments and/or non commercial researches on[8]

  Include description of forecast research

- "INFORMATION" in this agreement shall mean any information, oral or written of a confidential nature relating to the MATERIAL.

- "IP RIGHTS" shall mean all intellectual property rights including but not limited to inventions (whether patentable or not), innovations, copyrights, trademarks, plant variety protection, trade secrets and know-how, rights in confidential information whether registered or unregistered.

IN CONSEQUENCE WHEREOF THE PARTIES AGREE AS FOLLOWS

1 XXX undertakes to supply the MATERIAL to the Beneficiary after the signature of this agreement by both parties. The MATERIAL is supplied to the Beneficiary on a non-exclusive basis and for the sole purpose of research and experiment described above. Consequently, the Beneficiary undertakes to use the MATERIAL only to this end.

2 The MATERIAL is the property, in the possession or under the lawful control of XXX who holds and retains all right, title and interest in and to the MATERIAL l and/or INFORMATION and any IP RIGHTS thereof.

Consequently, the Beneficiary will not include the MATERIAL and/or the INFORMATION in patent application or other deed of industrial property without the preliminary written agreement of XXX and other MATERIAL owner(s) and/or right holders.

3 The Beneficiary will not proceed to manipulations or alterations, which could affect the rights of XXX on the MATERIAL, without the written and preliminary agreement of XXX. The Beneficiary is not authorised to combine, to mix or to incorporate the MATERIAL with another material except for the needs of the non-commercial test and experiments and/or non-commercial research, under the conditions defined in section 7. The Beneficiary undertakes to use the MATERIAL according to the national and international laws and regulations and will make his business of obtaining all authorisations needed to the conduct of its non-commercial research and experiments.

4 XXX, by this agreement, does not grant any right, title deed, right of license or exploitation right, implied or express, to the Beneficiary by the transfer of the MATERIAL, save express and written agreement of XXX.

5 The Beneficiary acknowledges the confidential nature of the MATERIAL and the INFORMATION and agrees:

- to supply this MATERIAL and the INFORMATION only in members of his permanent staff which agree to submit themselves to the provisions of this agreement;
- to take all reasonable measures to avoid that this staff discloses the MATERIAL, at a whole or in part, and/or the INFORMATION to third parties, even for free, without written and preliminary agreement of XXX.

The Beneficiary shall have the responsibility for implementing the obligations of this agreement towards every person having access to the MATERIAL and/or to the INFORMATION.

6 The obligations of confidentiality of the parties in this agreement do not apply to the INFORMATION and to the MATERIAL:

- - which are in the public domain at the time of their disclosure by one of the parties;
- - which fall in the public domain without any breach of this agreement;
- - which were legally supplied by a third party not being submitted to obligations of confidentiality;
- - which are already known by XXX and/or the Beneficiary before the coming into force of this agreement without having been communicated, directly or indirectly, by one of the Parties.

7 XXX shall be informed of any result obtained by the Beneficiary with the MATERIAL and XXX shall be free to integrate such results in DEXI-PM if it deems it necessary. Such results shall not be disseminated by the Beneficiary to third-parties without XXX 's prior written consent. Any authorized dissemination shall mention the origin and the name of the MATERIAL.

Use and dissemination conditions applying to the results which offer an evolution and /or an improvement of the MATERIAL shall be settled in a separate agreement between the Beneficiary, XXX and the other owners or right holders on the MATERIAL.

In case of original composed creation, i.e. a creation which integrates the MATERIAL, at a whole or in part, the Beneficiary may own such creation, subject to XXX rights.

DEXI-PM shall in any case remain the property of its, and/or their, original owner(s).

8 The MATERIAL supplied has an experimental nature. XXX gives no warrantee or representation as for its utility, efficiency, merchantability, non-toxicity, safety, fitness for a particular use. XXX declines any liability or responsibility concerning any and all damages caused by the MATERIAL and the INFORMATION, and by the use which could be made of it. XXX makes no representation or warranty that the use of the MATERIAL and/or INFORMATION will not infringe any patent or other proprietary right.

9 This agreement will come into effect in the date of its signature, for a duration of …….

At expiry of this agreement, XXX may request the Beneficiary to give the MATERIAL back or to destroy it, as well as any derived material. In any case, the obligations of confidentiality and secret contained in this agreement will be maintained as long as the INFORMATION and the results have not fallen in the public domain.

10 This agreement is governed by French law. The Parties will do their best to resolve amicably any dispute as for the interpretation or the performance of this agreement. In case of persistent disagreement, the Parties shall resort to the French courts jurisdiction.

In witness whereof, this agreement has been drawn up in two original copies.

……[date]……, ……[place]……

THE BENEFICIARY **XXX**