LIFE Project Number

<LIFE14 ENV/IT/443>

Public Final Report

Covering the project activities from 01/10/2015 to 31/12/2017

Reporting Date[1]

<30/04/2018>

LIFE PROJECT NAME or Acronym

<LIFETAN>

Data Project

Project location:	
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Data Beneficiary

Name Beneficiary:	Agenzia nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenibile
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[1] Include the reporting date as foreseen in part C2 of Annex II of the Grant Agreement

1. Table of contents

Summary

2. List of key-words and abbreviations

BAT	Best Available Technique
BOD	Biological Oxygen Demand
BP	Business Plan
CL	Chromium leather
CPs	Chlorinated paraffins
Cl-FAME	Chlorurated fatty acid methyl ester
COD	Chemical Oxygen Demand
COM	Commercial
DM	Dry matter
DPM	Deodorized Poultry Manure, PODEBA bating agent
DTG	Differential Thermo Gravimetry
EDF20	Defatting natural product
EDS	Energy Dispersive X-ray Spectroscopy
FAME	Fatty Acid Methil
FTIR	Fourier Trasform Infrared Sepctroscopy
GCMS	Gas Chromatography – Mass Spectrometry
GSA	Gelatin Sigma type A
GSB	Gelatin Sigma type B
KoM	Kick off meeting
LCA	Life Cycle Assessment
LHM	Laying Hen Manure
OXA	Oxazolidine
PCA	Principal Component Analysis
REACH	Registration Evaluation Authorization and restriction of CHemicals
SCl-FAME	Solfochlorurated fatty acid methyl ester
SCPs	Solfochlorinated paraffin
SEM	Scanning Electron Microscopy
SF	Standard Formulations
SS	Suspended Solid
TGA	Thermo Gravimetric Analysis
VOC	Volatile Organic Compounds
Wet blue	Leather during processing, after Chromium tanning
Wet white	Leather during processing, after Oxazolidine tanning

Legend for LIFETAN tanning cycle (Ltc)

Schematic diagram of the LIFETAN tanning cycles together with objectives of initial proposal

Table of MILESTONES

MILESTONES OF THE PROJECT

Name of the milestone	Number of the associated action	Deadline Foreseen	Deadline ACTUAL
Kick-off meeting	E1	15/10/2015	15/10/2015
LIFETAN website	D1	30/12/2015	30/12/2015
Natural products production for eco-friendly tanning cycle	B2	30/6/2016	30/6/2016
Reduction of Chromium in tanning wastewater (-20%)	C2	31/12/2016	31/12/2016
Natural products production for eco-friendly tanning cycle	B2	30/6/2016	2016-06-30
100 bovine and ovine leathers tanned with natural products	B4	31/3/2017	31/3/2017
50 sheep/goat skins leather tanned and 50 bovine skins leathers tanned using LIFETAN natural products	B5	30/6/2017	30/9/2017
100% of leather products production are using hides that have undergone a natural products tanning cycle	B6	31/12/2017	30/12/2017
LIFETAN leather products satisfy leather products quality standards	C6	30/9/2017	30/9/2017
Water saving (20%) and wastewater load reduction (20%); substitution of traditional recipes with natural formulations, with the overall chemical reduction	C5	31/12/2017	30/12/2017
LCA document production and assessment of socio-economic impact	C7	31/12/2017	30/12/2017

LIFETAN GANTT CHART

		2015				2016				2017				2018			
Action number	**Action title**	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV
B.1	Demonstration of the use of the different toxic and chemical products currently used in the EU tanneries				X	X											
B.2	Demonstration of natural products					X	X	X	X	X							
B.3	Demonstration of natural products in the whole tanning cycle at laboratory level					X	X	X	X								
B.4	Tanning at a semi-industrial level by using natural products						X	X	X	X							
B.5	Demonstration of natural products tanning at a pre-industrial level						X	X	X	X	X						
B.6	Leather products obtained with the use of natural products for the tanning cicle										X	X	X				
C.1	Monitoring of the toxic and chemical products environmental impact				X	X	X	X									
C.2	Environmental monitoring of tanning with natural products at laboratory level					X	X										
C.3	Environmental monitoring of tanning with natural products at semi-industrial level						X	X	X	X							
C.4	Environmental monitoring of tanning with natural products at the pre-industrial level							X	X	X	X						
C.5	Environmental benefits from the natural products tanning process								X	X	X	X	X				
C.6	Quality assessment of leather products production									X	X	X					
C.7	Monitoring of technical-socio-economic assessment of the LIFETAN project										X	X	X				
D.1	Website creation				X												
D.2	Innovative technology for leather industrial natural tanning manual									X	X	X					
D.3	Training courses and workshops in Italy and Spain									X	X	X	X				
D.4	Diffusion material preparation				X	X	X	X	X	X	X	X					
D.5	International conferences, events and fairs				X	X	X	X	X	X	X	X	X				
D.6	Networking				X	X	X	X	X	X	X	X	X				
E.1	Project management				X	X	X	X	X	X	X	X	X				
E.2	Monitoring				X	X	X	X	X	X	X	X	X				
E.3	Audit											X	X				
E.4	After-LIFE communication plan											X	X				

3. Executive Summary

This report represents the activities carried out during the whole project LIFE "Eco friendly tanning cycle - LIFETAN (LIFE14 ENV/IT/000443), over the period between 01/10/2015 and 31/12/2017.

The products of petrochemical origin are currently widely used in the tannery cycle due to their low cost and good performances, but they raise increasing concern for their high chlorine content and low biodegradability. Chlorinated have been widely used in the leather process, mainly because of their chemical stability, low cost and good application performances. Today, the need for eco-sustainability has changed the scenario: the high chemical stability, the low biodegradability and the high chlorine content represent severe limits to their use. The LIFETAN project aims at replacing them, proposing the development of new natural derivatives from vegetable oils, in order to tackle the biodegradability problem.

To have an idea of the global importance of the environmental problem addressed by the project, it is important to mention that about 75% of the European leather is produced in Italy and in Spain.

The LIFETAN project aimed at demonstrating the use of an innovative natural/naturalized products and technologies for the degreasing, fatliquoring, bating, dyeing and tanning phases of the whole leather tanning production, on the basis of the integration of the successful results of previous LIFE projects (OXATAN, ECOFATTING, ECODEFATTING, BIONAD and PODEBA); the new products substituted toxic and chemical products used during the leather tanning cycle, producing leathers and leather products with a significantly higher eco-sustainability profile.

The main beneficiaries involved in the specific previous LIFE projects were involved in the LIFETAN project in order to integrate the specific experiences of the single phases in the whole tanning cycle.

The feasibility of 5 specific "eco-friendly" tanning protocols was demonstrated; it will produce important results in the tanning and leather industries in terms of environmental and economic impact and new strategies for innovation.

Figure 3.1: LIFETAN tanning cycle

The project contributed to the protection of the environment and sustainable development through:

- The use of fatliquoring, defatting naturalized products which do not exceed the legal limits for hazardous substances in leather for the manufacture of leather goods, etc.,
- The use of fatliquoring, defatting products which allow leather manufacturers, as consumers of tanned leather, to obtain the European eco-label for their products, ensuring compliance

with the ecolabel parameters related to leather and its processing (chromium III content in wastewater, arsenic, cadmium and lead content in products, etc.),
- Reduced contamination in wastewater with biodegradability improvement,
- Recycling and use in an innovative application of a waste, poultry dejection, characterised by high environmental problems of management and disposal,
- The design and production of naturalized fatliquoring and dyes with "lactose" from waste milk serum,
- The application of the innovative oxazolidine (chromium free) tanning technology.

The main environmental, social and economic goal of LIFETAN project is the replacement of current commercial chemical and toxic products with natural and naturalized (obtained via chemical synthesis from natural products) products in the defatting phase of the tannery cycle, in order to establish a significantly eco-sustainable and profitable business for companies, from natural products manufacturing to tanneries and final leather products manufacturing.
The validation of the method was accomplished using chrome and vegetable tanned leathers by independent tanneries in Italy and in Spain, according to a cross-validation approach.
The added value for the project will be the reproducibility of the whole tanning process by independent tanneries in different environments conditions and using raw materials of different quality (i.e. bovine and calf hides, sheep skins, pig skins).
Finally, the following main technical objectives were achieved:

- The replacement of chemicals (Phthalates, Nonyl-phenol ethoxylates, Chlorinated paraffins, …) in the tanning process with the identification of 5 new LIFETAN tanning cycles, which use natural/naturalized products;
- The compatibility of natural and naturalized products for the whole tanning cycle, sometimes the interaction of some of these products, which allows to obtain special leathers, with physical and chemical properties in compliance with standards required for bag, garments, shoes and ecolabel for footwear;
- Reduced use of chlorine in the tanning cycle, by eliminating in the degreasing phase;
- The production of 200 leathers with the LIFETAN process/products by 2 tanneries;
- Manufacturing of 100 sample leather products using the natural products, in line with EU Ecolabel criteria for footwear;
- Increased biodegradability of the molecules used and therefore in wastewater (improvement connected to interactions between new products);
- An increase in penetration of dyes, tanning agents, resulting in better performance of the finished product;
- A reduction (28-30%) of pollutants in waste water from leather production measured;
- The demonstration of the technical/financial feasibility of chrome-free leather tanning, with not significant variations in costs for tanning production, with products still at pre-industrial scale;
- Thresholds of 20t/y and 5 t/y production for degreasing and fatliquoring agents respectively before R.E.A.C.H. registration;
- IPPC submission of Natural bating agent as Emerging Technique.

The LIFETAN tanning process/products are coherent with development strategies of tanning sector included the improvement in monitoring and digitalization (Industry 4.0).

No changes in water consumption during the tanning process were achieved, due to the will of not introducing further changes in industrial tanneries organizations.

In this Final Report we explain in detail in the chapters 4 and 5 the technical and administrative topics and organisations of the project and in the chapters 6, 7 and 8 the technical and financial results obtained during the project.

4. Introduction

Environmental problem/issue addressed

The European leather industry is committed to a socially and environmentally sustainable development. It is fundamental to provide these industries with innovative and eco-friendlier leathers that meet the European quality standards. In this sense, leather industries were going for a type of leathers that allow for the eco-design of products, which is currently more and more demanded by European end users.

The European leather industry is made up of 1,879 companies with an estimated turnover of 7,460 million euros in 2007. Most of these tanneries are Small or Medium Sized companies, and employ about 28,000 people (BREF TAN, 2013).

In the EU, leather industries are concentrated in Southern countries, of which Italy and Spain are the most important producers of tanned leathers and products manufactured thereof. For this reason, the LIFETAN project was developed by RTD Centres and SMEs from Spain and Italy, aimed at demonstrating, promoting and disseminating the innovative natural products tanning technology throughout the whole European Union.

Furthermore, the crisis that the leather sector is currently experiencing, as well as competition from low-wage third countries entails the need for the introduction of new market strategies. In this sense, for the European leather industries it is very important to introduce innovative leather tanning techniques alternative to traditional cycle available, so as to improve their environmental behaviour and social acceptance, at the same time that they improve their competitiveness with regard to leathers produced in other extra-community countries. Likewise, European leathers are well-known and appreciated by European leather manufacturers and consumers as example of quality and healthy products.

Outline the hypothesis demonstrated by the project

On the basis of the integration of the successful results of previous LIFE projects, the LIFETAN project demonstrated that innovative natural & naturalized products and technologies for the degreasing, fatting, bating, dyeing and tanning phases were able to substitute toxic and chemical products used during the leather tanning cycle.

The goal was to produce new or existing leather products with significantly higher eco-sustainability profile, which represents a business for companies.

LIFETAN project contributed to the protection of the environment and acted primarily for a sustainable development of the leather business through:

- The use of natural products from renewable sources, often obtained from agro-industrial by-products (poultry manure and lactose), developing circular economy practice,
    - Recycling and use in an innovative application of a waste/by-product, poultry dejection, characterised by high environmental problems of management and disposal,
    - The use of "lactose" from waste milk serum to generate naturalised dyes, impacting heavily on the disposal of this highly hypertrophic substance and naturalized degreasing agent, avoiding Cl-compounds and Nonyl-phenol ethoxylates,
- The use of the innovative oxazolidine (chrome-free) tanning technology.

Description of the technical solution

The LIFETAN project consisted in different actions for demonstrating that the innovative natural products technique can be applied, mainly at a preindustrial scale. Therefore, this project aimed at demonstrating the use of the natural products technique at three levels:

1st. Laboratory level: ENEA, INESCOP and ICCOMCNR used laboratory equipment and materials for demonstrating the new natural products and processes at a laboratory level.

The results of the lab demonstration were useful basis for the semi-industrial level.

2nd. Semi- industrial level: Newport and INESCOP used pilot tanning drums for the demonstration of the new natural products and process at a semi-industrial scale.
3rd. Pre-industrial level: NEWPORT) and TRADELDA tested the production of leather using the natural products LIFETAN tanning technique at an industrial scale, up to 1700 kg batch.
Training actions, targeted to Spanish and Italian tanners, were performed.

Expected results and environmental benefits
The main project LIFETAN results quantification consisted in:

- Lab, semi and pre-industrial tests and analyses with the new products showed:
  - Less (28-30%) pollutants in bath wastewaters. (- 50% TKN deliming-bating stage, Cr -100% tanning stage, COD -16% average) for calf and bovine hides and lamb skins,
  - Biodegradability improvement,
  - Toxicity reduction of Cl in the tanning cycle, eliminating from the degreasing phase,
  - Substitution (100%) of traditional recipes based on raw materials of petrochemical origin with new formulations specific to defatting phase,
  - Increase in the biodegradability profiles of the molecules used,
  - Increased penetration of products into derma, resulting in better performances of the finished product,
  - Consistent dye penetration into leather, to obtain colour homogeneity.
- Definition of 5 new tanning formulations by using the project natural products, LIFETAN tanning cycle 1-5, capable of inducing high performances, specific properties of the leather & high aesthetical profile as for touch and fullness.
- 50 sheep/goat skins and bovine leathers tanned with the use of the natural products.
- 100 leather products manufactured with leathers produced at pre-industrial level, which complies with the European Eco-label criteria.
- Demonstration of (20%) reduction of Chromium salts in tanning with natural products.
- Demonstration of the technical feasibility of chrome-free leather tannage using the in LIFETAN tanning cycles, with oxazolidine.

Expected long-term results
The environmental LIFETAN goal was to improve the safety profile of the business for environmental compatibility and the eco-sustainability of leather goods manufacturing to pursue cost-effective strategies. LIFETAN demonstrated the replacement of current commercial toxic products, in order to establish a significantly eco-sustainable and profitable business for tannery companies, along the whole chain.
Additionally, LIFETAN results contribute to the innovation policies of the EU, as Circular Economy, contribution to BAT technique identification ad proposal, LCA developed for LIFETAN cycles. Finally, it is important to highlight that the development of LIFETAN project supported the application of the Environmental Technologies Action Plan (ETAP), whose objective is to further environmental technologies to improve the environment and European competitiveness supporting eco-friendly technologies since they are good for business, reduce pressure on the environment and can create new jobs.
New jobs are foreseen in natural/naturalized product development and manufacturing. The replicability of the demonstrated technology can be based on a gradual scale up for their production, starting from a modular production unit, in some cases under threshold for REACH registration.
First applications in niche sector, in order to use smaller quantities and also tick an initial price higher if it guarantees special performances (i.e. on color), with direct test with natural/naturalized products to check special application with results codified in Emerging Technique to be included in BREF TAN. LIFETAN is essential as visibility for market entry.

5. Administrative part

The LIFETAN project proceeded smoothly and all actions were completed as foreseen. During all project phase, the LIFETAN project has benefited from close collaboration between all beneficiaries and has maintained close contact with all through different media: emails, telephone, meetings, etc.
The LIFETAN management process needed daily work to maintain a permanent flow of action with the aim of achieving the objectives set. The specific management activities carried out are detailed in paragraph 6.1.20 "Project management".
The management of the project was carried out in compliance with what was established in the proposal approved by the European Commission, with all partners acting in compliance with the Grant and Partnership Agreements.
The project management structure is composed of the 5 beneficiaries, plus the EC and the LIFE external team (Figure 5.1). In particular, the LIFETAN beneficiaries' added values are:

- ENEA, project coordinator, a public Italian research organisation, expert in material characterisation and analysis and project management,
- ICCOMCNR, a public Italian research organisation, specialist and responsible of chemical analysis,
- NEWPORT, an Italian tannery responsible for tanning demonstrative tests in Italy,
- INESCOP, a Spanish innovation center expert in tannery sector and responsible for the material and tanning laboratory tests,
- TRADELDA, a Spanish tannery responsible for the tanning demonstrative tests in Spain.

In particular, the LIFETAN beneficiaries defined the following two management structures:

- **Technical Committee,**
- **Administrative Committee.**

During all project phases, the four associated beneficiaries participated in project management activities keeping in smooth contact with the project coordinator and the other beneficiaries. They prepared and attended the project management meetings and collaborated with the project coordinator (ENEA) for this Final Report, as set out in the project proposal.

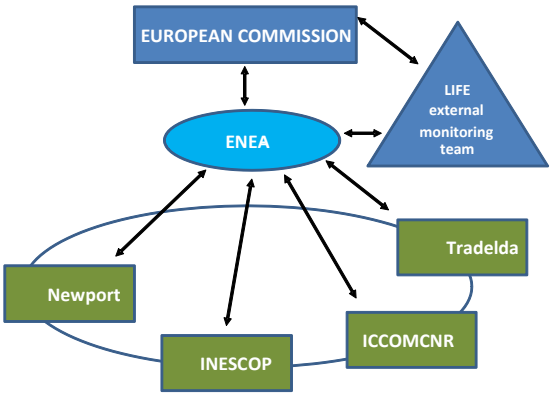

Figure 5.1. LIFETAN management structure

During the whole project period, monitoring tasks have been carried out for each action, in particular:

- ENEA, as project coordinator, had continuous contacts with all project beneficiaries for monitoring project activities
- ENEA, as coordinating beneficiary, prepared and sent a monthly indication of operative activities to be done to all the partners
- ENEA, as coordinating beneficiary, every month sent a report to the monitor of LIFE's External Assistance Team on the progress of the project, allowing a tight follow-up of the LIFETAN project.

6. Technical part

6.1. Technical progress, per Action

6.1.1. Action B.1 Demonstration of the use of the different toxic and chemical products currently used in the EU tanneries

Objectives:
Definition of the toxic products in the tanning process at the bating, defatting, tanning, fatting and dyeing stages in order to evaluate which products should be removed from the tanning process formulations and to find information on potential natural substitutes less dangerous and polluting.

Activities:

According to the proposal, firstly NEWPORT and TRADELDA in their tannery premises have analysed their different tanning cycle processes and have selected the toxic products of their traditional tannery cycles.
After that, INESCOP has carried out an information search about:

- ✓ which products are restricted by UE regulations due to its high toxicity on the human health and on the environment
- ✓ the environmental impact of these products in order to use these parameters as a standard against which the improvement of the quality of the LIFETAN products is to be compared and was useful also in the definition of the project outcome indicators

Finally, ENEA, ICCOMCNR and INESCOP have demonstrated what interactions occur between the product and the leather substrate with the objective to evaluate the potential natural substitute products effectiveness. According to the work carried out, we could conclude that the main environmental impact and hazardous substances in the tanning process at the bating, defatting, tanning, fatting and dyeing stages are:

TANNING STAGE	TRADITIONAL PRODUCT	ENVIRONMENTAL IMPACT
Bating	Enzymatic products	Presence of ammonium in wastewater
Defatting	Alkylphenol and alkylphenol ethoxilates	Restricted substances (EU regulations)
Tanning	Chromium salts/ Chromium III	Restricted substances (EU regulations)
Dyeing	Azocolorants and azodyes Acid dyes mixed with surfactants, dispersing agents, paraffin, inorganic salts, etc.	Restricted substances (EU regulations) Increase of conductivity and non-biodegradable organic load in wastewater
Fatting	Chlorinated paraffins short chain (C10-C13)	Restricted substances (EU regulations)

Table 6.1. Summary of toxic products in the tanning process

This action has been completed by 100% and all these results have been compiled in Deliverable Action B.1. “Demonstration of the use of different toxic and chemical products currently used in the EU tanneries”.

6.1.2. Action B.2 Demonstration of natural products

Objectives:

- Definition of natural based products for bating phase, degreasing, tanning, dyeing, fatting phases in order to define eco-friendly tanning cycle
- Evaluation of natural products as the substitutes of standard chemicals and exploration of their compatibility for their simultaneous use in the process
- Evaluation of sustainable processes to produce natural products in the tanning cycle

Activities:

The following five products have been selected and purchased according in the quantity necessary to carry out all the activities foreseen in the proposal. For PODEBA bating agent a second order was made to have enough products to carry out demonstrative tests at scale proper for preindustrial: 2 tests with tanning of 1700 and 1000 kg for batch.

PROJECT	**PHASE**	**NEW PRODUCT** (acronym/label)	**CHARACTERISTICS**
PODEBA	BATING	PODEBA (PODEBA bating agent)	Natural products from poultry manure
ECODEFATTING	DEGREASING	EDF20	Mixture with naturalized product from lactose
OXATAN	TANNING	OXA Oxazolidine	Organic from synthesis (condensate aldehydes)
ECOFATTING	FATLIQUORING	Cl-FAME,	Naturalized product from palm kernel oil for mixture
BIONAD	DYEING	NAT DYE Naturalized pigments	Mixture with naturalized product from lactose

Table 6.2: LIFETAN products and characteristics

Podeba bating agent is a natural product, obtained from special kind of poultry manure after undergoing a patented process for treatment, and it used directly without need of formulations in tanning cycle.

EDF20 is already a formulated product; it contains water (45%), ethoxylates (neither phenyl nor nonyl) 20% and a naturalized product derivate from lactose via chemical synthesis (5%).

At the same time the fatliquoring agent has to be used as a formulation. The fatliquoring agent is a mixture, where the Chlorinated fatty acid methyl ester mixture (FAME), (Cl-FAME) from Palm kernel oil represents about 20% of the total.

Naturalized products require REACH registration for industrial scale production. ECHA was consulted via two specific questions submission for degreasing and fattening agent. Therefore, it is possible to produce (under threshold) 20 t/y of EDF20, corresponding to 1t/y of product 5 – lactose derivate, and 5 t/y of Fatliquoring agent, corresponding to 1 t/y of Cl-FAME product.

Figure 6.1: LIFETAN natural/naturalized products

All the obtained results are detailed in the Deliverable Action B2 “Demonstration of natural products”.

6.1.3. Action B.3 Demonstration of natural products in the whole tanning cycle at laboratory level

Objectives:

- Definition of LIFETAN tanning formulations
- Laboratory level trials by comparing commercial and natural bating agents and its influence in the chrome tanning process
- Laboratory level trials for 20% Reduction of use of Chromium in tanning phase
- Laboratory level trials comparing several combinations of commercial and natural bating, defatting and tanning agents, evaluating its environmental impact and the quality of the leather obtained.

Activities:

According to the proposal, INESCOP, TRADELDA and NEWPORT have defined the LIFETAN tanning formulations which were optimized and demonstrated by means of semi and pre-industrial trials at Actions B.4 and B.5. INESCOP has carried out the laboratory-scale leather tanning trials at its facilities using natural products.

Two sets of wet-blue leather samples were produced. The first one, made of four leather samples bated and defatted by natural/naturalized products and tanned with different Chromium concentration (4, 5, 6, 8 %w), to evaluate the effectiveness of the Chromium amount reduction in the tanning phase. The second set, consisting of eight samples, aimed at comparing standard processes and natural phases of bating and defatting, with or without Chromium in the tanning phase.

ATR-FTIR spectroscopy was employed in order to study the interaction of tanning agents with leather), Thermal analysis (TG and DTG) in order to study the leather thermal stability and SEM-EDS characterization for the morphological analysis and semi-quantitative composition.

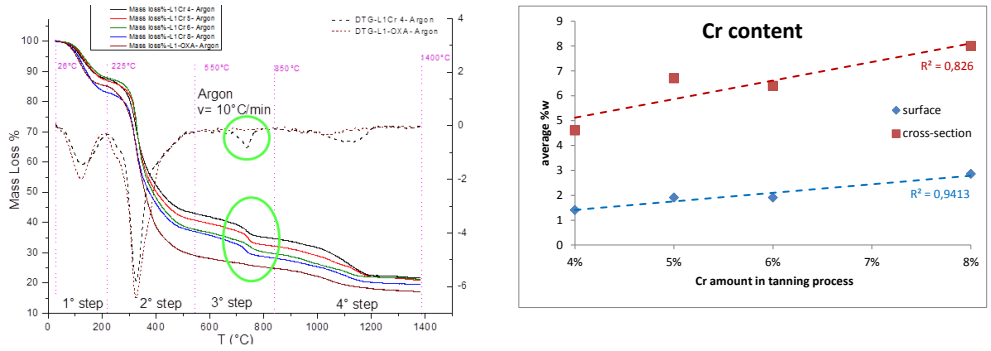

Figure 6.2: TG, DTG and EDS results on leather samples tanned with different Cr concentration

The most significant considerations to be derived from the samples characterization confirmed the effectiveness of the Chromium amount reduction in the tanning phase and natural products in the bating and defatting phases.

All the obtained results are detailed in the Deliverable Action B3 “Demonstration of natural products in the whole tanning cycle at laboratory level”. A detailed discussion of the FTIR, TGA and SEM-EDS characterization is given in the ANNEX N°1, 2 and 3 of the Del. B3 “Demonstration of natural products in the whole tanning cycle at laboratory level”.

6.1.4. Action B.4 Tanning at a semi-industrial level by using natural products

Objectives:
Different types of hides at a semi-industrial level underwent complete tanning cycle using natural products alongside toxic and chemical products.

Activities:
Newport started its activities by testing PODEBA bating agent in comparison with commercial products in order to verify the methods of use and the quantity (% pelts w/w) proper for own "tanning system" and types of leather and Oxazolidine, with different tests. Different effects have been observed: no particular problems with odour aspects were observed, with reference to tannery conditions; some brown deposit remains in the “flesh side” after bating, but no trace at the end of the process; the dosage has to be slightly modified in comparison with PODEBA manual; the tests were useful to address a Newport knowledge of the natural products. Newport processed 50 bovine hides (bellies) at pre-industrial level.

In parallel, INESCOP and TRADELDA have performed semi-industrial level trials comparing several combinations of commercial and natural bating, defatting, tanning, fatting and dyeing agents, in order to evaluate the behaviour of natural products with respect to commercial products and, after that, monitoring the environmental impact of the different process combinations. A total of 20 calf hides and 80 lamb skins, with a total weight of 400 were used.

	Bating	Defatting	Tanning	Fatliquoring	Dyeing
CALF_CR	PODEBA bating agent (Podeba project)	EDF-20 (Ecodefatting project)	CR	FAME	BIONAD + COMMERCIAL
CALF_OXA	PODEBA bating agent (Podeba project)	EDF-20 (Ecodefatting project)	OXA	FAME	BIONAD + COMMERCIAL
LAMB_CR	PODEBA bating agent (Podeba project)	EDF-20 (Ecodefatting project)	CR	FAME	BIONAD + COMMERCIAL
LAMB_OXA	PODEBA bating agent (Podeba project)	EDF-20 (Ecodefatting project)	OXA	FAME	BIONAD + COMMERCIAL

Table 6.3. Crust leathers processed by INESCOP

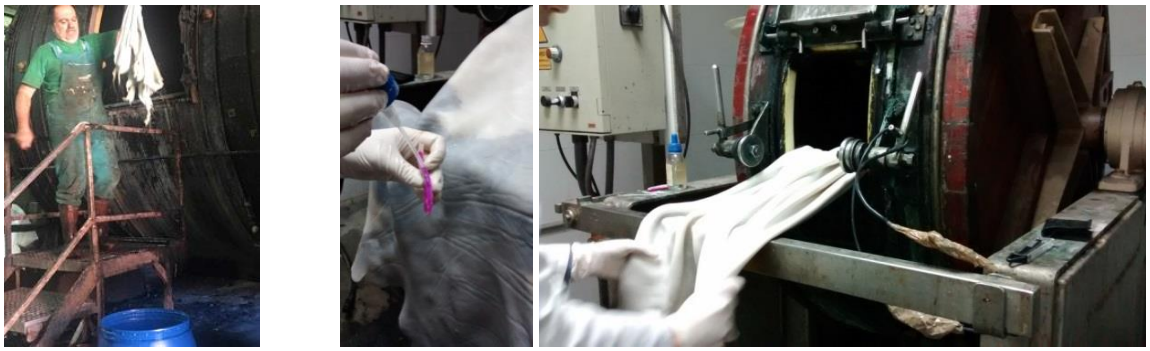

Figure 6.3 Selection and extraction of PODEBA bated pelts c/o Newport and leather processing with LIFETAN natural products at semi-industrial level c/o INESCOP

The obtained leathers have good physical strength and adequate smoothness, softness, fullness and flexibility showing a good behaviour of the combination of the five natural products tested in these trials as bating, defatting, tanning, dyeing and fatliquoring agents.
FTIR characterization, thermogravimetric analysis (TGA) and SEM-EDS results show that the use of innovative natural products for the bating, defatting and dyeing phases, and the replacement of Chromium with Oxazolidine in the tanning phase did not significantly affect the leather morphology and composition. Finally, the Oxazolidine tanning allowed obtaining calf crust leathers with almost the same composition, both in surface and in the cross-section, pointed out remarkable process uniformity.
A detailed description of these tests is given in the Del. B4 "Tanning at a semi-industrial level by using natural products" and its Annexes.

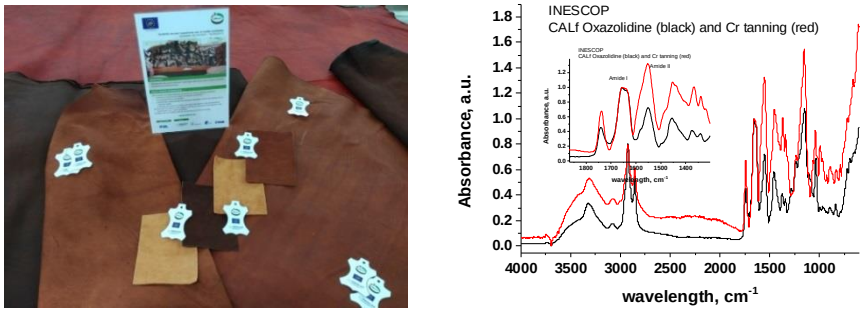

Figure 6.4. LIFETAN natural leathers obtained al semi-industrial level and representative FTIR spectra

6.1.5. Action B.5 Demonstration of natural products tanning at a pre-industrial level

Objectives:
Different types of hides at a pre-industrial level underwent complete tanning cycle using natural products alongside toxic and chemical products.

Activities:
A first set of demonstrative tests were carried out with the 5 natural products on bovine hides (fresh salted cow bellies). Crusts were produced comparing LIFETAN tanning cycle with standard vegetable and Cr tanning, as reported in table 6.4 and shown in Figure 6.5.

	Bating	**Defatting**	**Tanning**	**Fatliquoring**	**Dyeing**
NW_1	Commercial product	Commercial product	Tannins Vegetable	Comm. product	Comm. product
NW_2	Commercial product	Commercial product	Cr	Comm. product	Comm. product
NW_3	PODEBA bating agent	EDF20	OXA + Cr	Comm. product	Comm. product
NW_4	PODEBA bating agent	EDF20	OXA + Cr	FAME	BIONAD
NW_5	PODEBA bating agent	EDF20	OXA +ATO	FAME	Comm. product
NW_6	PODEBA bating agent	EDF20	OXA+ ATO	FAME	BIONAD

Figure 6.4: Crust leathers processed by Newport

A second set of demonstrative pre-industrial level tests were carried out at 1000 kg scale:

- Comparative test on bovine hides (bellies),
- quantity n° 285 bovine bellies,
- fresh salted raw hides weight 1700 kg.

The 285 bellies were divided into 3 batch: N° 95 bellies to be treated with a classic tanning with 8% on pelt weight of commercial trivalent chromium salts; N° 95 bellies to be treated with 5% of OXA product + 5% on pelt weight of commercial trivalent chromium salts (Ltc 3); N° 90 bellies to be treated with 5% of OXA product and 15% Quebracho (vegetal extract) (Ltc 2).

Figure 6.5: Crust leathers processed by Newport at pre-industrial level

In order to improve knowledge of alternative products to be used in the tanning process, as Newport, also TRADELDA has started its activities by testing PODEBA bating agent in comparison with commercial products in order to verify the methods of use and the quantity (% pelts w/w) proper for own "tanning system" and types of leather. Also bovine hides and sheep skins have been purchased.

TRADELDA have performed pre-industrial level trials comparing several combinations of commercial and natural bating, defatting, tanning, fatting and dyeing agents (Action B.5), in order to evaluate the behaviour of natural products with respect to commercial products and, finally, monitoring the environmental impact of the different process combinations (Action C.4). The pre-industrial scale leather fat-liquoring trials were conducted at TRADELDA facilities in rotating tanning drums made of bolondo wood and featuring systems for automation, control and dosage of water and reactants.

Figure 6.6: Pre-industrial scale rotating drums at TRADELDA facilities and obtained LIFETAN natural letaher

TRADELDA produced a first set on calf hides and lamb skins, processing around 200 kg in each trial in order to check the process at a higher level (calf hides 12-15 kg/ lamb skin 3-5 kg). Both samples were treated with natural products in bating (PODEBA bating agent), defatting (ECODEFATTING defatting agent), tanning (oxazolidine), fatting (ECOFATTING fatliquoring) and dyeing (BIONAD dyeing) phases (Ltc 4).

Moreover, TRADELDA also carried out a second set only on calf hides, processing around 1000 kg in order to get a higher mechanical effect in the drums, higher penetration of the natural products and lower pollution in the residual baths.

	Bating	Defatting	Tanning	Fatliquoring	Dyeing
TRA1_CALF_OXA	PODEBA bating agent	EDF-20	OXA	FAME	DYE BIONAD
TRA2_CALF_OXA	PODEBA bating agent	EDF-20	OXA	FAME	DYE BIONAD
TRA_LAMB_OXA	PODEBA bating agent	EDF-20	OXA	FAME	DYE BIONAD

Table 6.5. Crust leathers processed by TRADELDA

Finally, INESCOP carried out an additional trial by using pig hides in order to evaluate the behaviour of this type of leathers. Both samples were treated with natural products in bating (PODEBA bating agent) and defatting (ECODEFATTING defatting agent) phases. The purpose was to compare Chromium and Chromium-free tanning phase. Both crust leathers showed similar thickness, but the Chromium tanned pig exhibited higher softness and flexibility than the Oxazolidine tanned pig which was a bit harder. Furthermore, the Oxa tanned leather showed a lighter colour than the Cr tanned pig.

	Bating	Defatting	Tanning
PIG_CR	PODEBA bating agent	EDF-20	Cr
PIG_OXA	PODEBA bating agent	EDF-20	OXA

Table 6.6. Tanned leathers processed by INESCOP

The results showed that by tanning with natural products, the obtained leather had good physical strength and adequate smoothness, softness, fullness and flexibility showing a good behaviour of the combination of the five natural products tested in these trials as bating, defatting, tanning, dyeing and fatliquoring agents. Moreover, a new product ("raggrinzito effect") was obtained with LIFETAN cycle (Ltc 2), with special characteristics.
A detailed description of these tests is given in Deliverable Action B5 "Demonstration of natural products tanning at a pre-industrial level". The characterization results obtained by FTIR, TGA and SEM-EDS analysis are detailed shown in the ANNEX N°1, 2 and 3 of the Del. B5 "Demonstration of natural products tanning at a pre-industrial level", confirming the effectiveness of using innovative natural/naturalized products within the tanning cycle, even processing hides amount higher than 1000 kg.
Since all the samples prepared and analysed in B5 action required the simultaneous use of one or more natural agents combined with commercial ones, in the global interpretation of the effect of LIFETAN process on the collagen conformation the statistical approach of PCA was mandatory (Figure 13). Legend and explanations in Del. B5.
Principal component analysis (PCA) simplifies the complexity in high-dimensional data while retaining trends and patterns. PCA is an unsupervised learning method and is similar to clustering—it finds patterns without reference to prior knowledge about whether the samples come from different treatment groups or have significant differences.

The LIFETAN samples were distinguished in the side of PC-1 (F1 x axis): Cr(III)-tanned samples (tanning 1 and 5) grouped in the negative side and were characterized by helix and intramolecular beta sheets. Vegetal tanning (tanning 2 and 4) with or without oxa grouped on the positive side of PC1 (F1 x axis) and were characterize by intermolecular beta sheets. PC1 also discriminated commercial agents (bating 1, fatting 1, defatting 1 on the negative side) from natural ones (bating 2, fatting 2, defatting 2 on the positive side). Dyeing was irrelevant in this grouping.

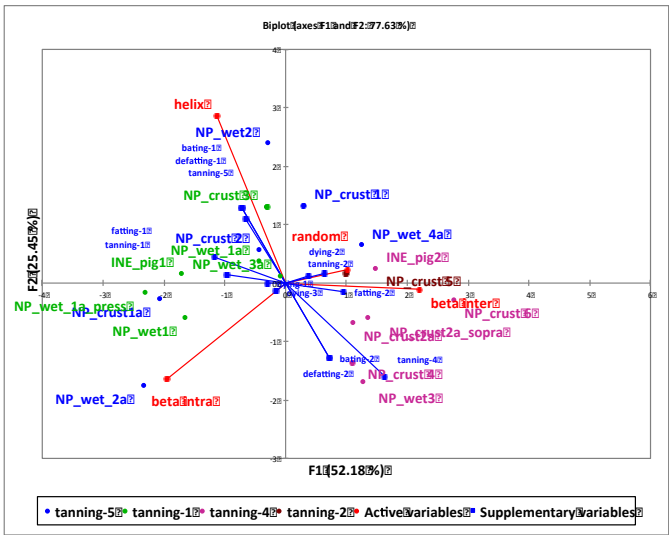

Figure 6.7: Loading and score plot of the first two PCs from PCA on secondary structures of 19 leather LIFETAN samples. Tanning:1) 8% Cr(III)-standard; 2) vegetal tanning; 3) oxazolidine; 4) oxa-ato; 5) oxa-Cr(III). Bating: 1) commercial enzyme; 2) PODEBA. Defatting: 1) commercial; 2) EDF20. Dyeing: 1) raw, no dye; 2) commercial acid dying; 3) BIONAD. Fatting: 1) commercial; 2) natural FAME.

Commercial agents, i.e. the interaction of Cr(III) interacts with COO- groups of collagen, promote the formation of helix and intra-molecular beta sheets. The natural agents, i.e. the interaction of oxazolidine and tannins with amino groups, promote the formation of inter-molecular beta sheets.

In both cases (commercial and natural agents) the global tanning process (conventional or using LIFETAN products) increases in leather the percentage of ordered structures.

PCA results demonstrated also that the natural agents, formulations and procedures proposed in LIFETAN project avoided the possible drawback of natural agents. i.e. the formation of stacking interactions between natural agents10 that would have prevented their interaction with collagen fibers.

6.1.6. Action B.6 Leather products obtained with the use of natural products for the tanning cycle

Objectives:

Leather obtained at semi-industrial and pre-industrial scale with LIFETAN process/products by NEWPORT, TRADELDA and INESCOP were used to manufacture leather goods, in particular, shoes, bags, garment in order to check the validity of the proposed process.

Activities:

First of all, chemical validations (chromium (VI), formaldehyde, aromatic amines, heavy metals, etc.) were carried out on hides produced to manufacture footwear and other leather articles. These validations were carried out at INESCOP's laboratories, which are equipped to carry out these types of assessments, with TRADELTA and NEWPORT support.

The quality assessment of the production of footwear with oxazolidine tanned hides is done through chemical validations in accordance with accepted standards (EN, ISO, etc.), and by checking the compliance with the criteria of the European Eco-label for footwear (Decision 2002/231/EC).

The chemical test carried out on all leather types show the compliance with the minimum recommended values for the manufacture of footwear and other leather articles. However, it is necessary to treat LIFETAN natural leathers tanned with oxazolidine at the end of the production process using a reducing compound (hydroxylamine sulphate) to remove formaldehyde from leather.
After that, the suitability of these leathers was proven by manufacturing different leather articles. Finally, meetings were held with leather articles companies in order to collect information about the performance of these leathers in the production of leather-goods.

In Italy, Newport commissioned CALZ.CIO S.C.O.R.P.I.O. SRL shoes (25 pairs) production with bovine hides processed according to LTC 3, while hand bags (6), wallets and accessories (18) were produced by FENIX with bovine hides processed according to LTC 2. 1 bag (experimental) was produced with LTC 2 leather. Manufacturing companies are located in the Tuscan district.
At Spain, footwear manufacturing industries are located in the geographical area of Alicante, in the municipalities of Elda, Elche, Villena, etc. where INESCOP and TRADELDA have their premises. Therefore, in the case of Spain, LIFETAN natural leathers have been used for the manufacture of footwear models (calf leather, according to Ltc 4, prepared for shoes) by SJOSTROM SHOES, S.L. in Petrer (Alicante).
In this context, several footwear models were produced using these obtained leathers as raw material (see figures below) and there are not problems during the manufacturing process.

Figure 6.8: LIFETAN products with Newport LIFETAN leathers

Figures below show also a selection of the footwear styles manufactured, in which a good performance of leathers tanned with natural products was observed throughout the various process stages (cutting, closing, setting, finishing).

Figures 6.9: Footwear made with leathers obtained using natural products in Spain

On the other hand, according to the feedback of leather goods manufacturers, the production processes are carried out as usual and no differences are observed in the cutting, lasting, closing, cementing processes or in the final appearance of the models produced.

A detailed description of all obtained results is given in Del. B6 “Leather products obtained with the use of natural products for the tanning cycle”.

6.1.7. Action C.1 Monitoring of the toxic and chemical products environmental impact

Objectives:

Evaluate the environmental impact of traditional products in the residual baths of each problematical stage: bating, defatting, tanning, dyeing and fatliquoring.
Production of a detailed technical study with the analysis of the environmental impact of the different tanning agents most used by European tanneries, in order to be able to compare them with the impact of the proposed natural products

Activities:

A first data collection and analysis was performed, simultaneous to Action B1, taking into account the expertise of the previous projects and also the suggestions from BAT (Best Available Technologies) for the tanning of hides and skins[2].
Firstly, INESCOP has selected the basic tanning cycle products most commonly used by European tanneries at the bating, defatting, tanning, dyeing and fatliquoring stages and then, INESCOP has determined different contamination parameters in samples of these products.
Next, INESCOP has carried out some tanning trials on cattle hides at pilot scale with commercial products and has analyzed the residual baths of every stage with the objective of analysing the environmental impact of each product used, in order to have an average to compare the results of the LIFETAN products over traditional products
The main results of these analyzes, which were considered as reference values, are shown below:

PARAMETER STAGE	DELIMING / BATING	DEFATTING	TANNING	DYEING	FATLIQUORING
pH	8.0	7.0	4.0	3.0	3.8
Conductivity (µs/cm)	9,500	114,000	69,000	11,300	2,750
COD (mg O2/l)	2,500	7,600	131000	5,600	15,300
BOD (mg O2/l)	1,600	2,700	37,000	1,000	6,300
Biodegradability	----	0.35	0.28	0.18	0.40
TNK (mg/l)	1,300	---	3,000	---	---

Table 6.7 Reference values in the residual baths of each stage.

All results have being compiled in Del. C.1 about “Environmental impact of the different tanning agents most used by European tanneries”.

[2] COMMISSION IMPLEMENTING DECISION, of 11 February 2013, establishing the best available techniques (BAT) conclusions under Directive 2010/75/EU of the European Parliament and of the Council on industrial emissions for the tanning of hides and skins. 16.2.2013 Official Journal of the European Union L 45/13

6.1.8. Action C.2 Environmental monitoring of tanning with natural products at laboratory level

Objectives:

Evaluate the environmental impact and the quality of the leather obtained in the laboratory level trials of several combinations of commercial and natural bating, defatting and tanning agents, in order to compare the behaviour of natural products and commercial products.

Activities:

The evaluation of the environmental impact was achieved by the characterisation of the waste-baths obtained in the different tests carried out, determining the most significant parameters in accordance with international standards.
The table below shows the results of the characterization of residual baths from the bating/defatting stage:

Ref:	pH	Conductivity (µS/cm)	COD (mg/l)	BOD_5 (mg/l)	TNK (mg/l)	Biodegradability
1 (ENZ + DG)	8,64	13810	7300	1387	1650	0,19
2 (PODEBA + DG)	8,36	15620	7900	1896	932	0,24
3 (ENZ + EDF20)	7,91	5770	12900	4700	1360	0,35
4 (PODEBA + EDF20)	8,15	10700	14800	5290	880	0,36

Table 6.8. Characterization of residual baths from the bating/defatting stage

The lower Conductivity values have been obtained at trial 3 and 4 by using the natural defatting product (ECOD) in substitution of a commercial product (Ethoxylated fatty alcohol). These trials have higher COD and BOD values due to the higher defatting effect and the chemical composition of the Ecodefatting products which is a derivate of lactose, but in this case, the biodegradability of the residual baths is a 70% higher employing the EDF20.
Regarding to the nitrogen content in the bating/defatting residual baths, the lower values has been got employing the PODEBA and this reduction is higher by using in combination with the EDF20, Ecodefatting natural product.
A detailed description of these tests, also with respect to picking/tanning and post-tanning stages, is given in Del. B3 “Demonstration of natural products in the whole tanning cycle at laboratory level” and its Annexes.

In conclusion, regarding the environmental impact, the ***laboratory trials*** shows:
- an important increase in the COD and BOD in the global effluent with a higher biodegradability of the residual baths is a 78.5% higher employing the LIFETAN process,
- a significant reduction in the TKN of the global effluent, around 40%.

A detailed comparison of obtained versus expected results are included in del. B3/C2.
Finally, it is important explain that laboratory level trials have been carried out employing small leather samples in small tanning drums with low mechanical effect, so this results should improve at the semi-industrial and pre-industrial trials.

6.1.9. Action C.3 Environmental monitoring of tanning with natural products at semi-industrial level

Objectives:

An environmental assessment of the new tanning cycle compared to traditional tanning cycle was made. To achieve this, physic-chemical analysis and a life cycle assessment (residual water, residues, etc.) were carried out.

Activities:

A planning of samples and parameters to be measured in order to obtain data to be used for Project performance Indicators has been agreed between all partners.
This first set of data was used to verify if environmental impacts with natural products are lower / comparable with Best Available Technique (BAT) or with emerging techniques. This activity is preparatory to draft a report for IPPC bureau. The results were included in Deliverable C5 "Report on environmental benefit from LIFETAN cycle".
The environmental evaluation of the results of the semi-industrial tests has been done through the characterization of the effluents in accordance with international standards.
Graphs below show the results of the characterization of residual baths from the bating/defatting, from the pickling/tanning stage and from the post-tanning stage for LTC 4:

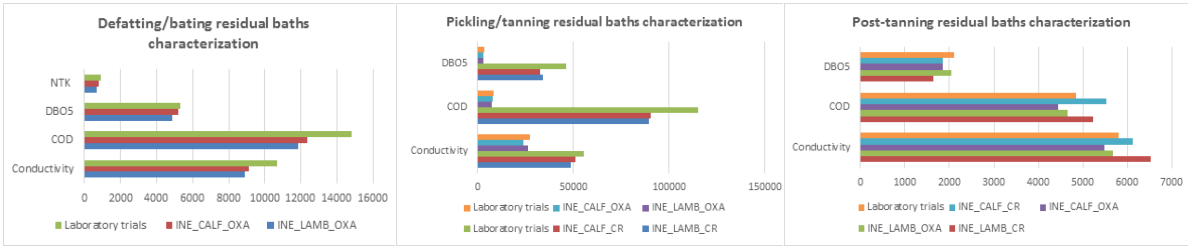

Figure 6.10. Analyses of residual baths from the bating/defatting, pickling/tanning stage and post-tanning stage

After the tanning process, leather samples processed by using natural products at the bating (PODEBA), defatting (EDF20) and tanning (OXA) stages, were neutralized, retanned, dyeing and fatliquoring in order to evaluate the behavior of naturalized dyes and Ecofatting products on these leather samples. These trials show that regarding to the conductivity, COD, BOD and biodegradability, chromium tanning has a higher environmental impact on wastewaters than natural tanning process. In addition, oxazolidine tanning effluents are chromium-free. This way the management of wastewater sludge is simpler and it can be reused, for instance, in agriculture. By the way, the obtained leathers have good physical strength and adequate smoothness, softness, fullness and flexibility showing a good behaviour of the combination of the five natural products tested in these trials as bating, defatting, tanning, dyeing and fatliquoring agents.
In short, the main advantage of the natural tanning process is that it allows more environmentally-friendly leather to be obtained, which in turn has similar appearance, quality, properties and applications to those achieved using conventional tanning processes with a lower environmental impact and with wastewater and wastes more biodegradables.
A detailed description of these tests is given in Del. B4 "Tanning at a semi-industrial level by using natural products" ant its Annexes, just as the comparison of wastewater for LIFETAN and traditional Cr tanning cycle.

6.1.10. Action C.4 Environmental monitoring of tanning with natural products at pre-industrial level

Objectives:

The pre-industrial level of the use of new natural products for tanning cycle was monitored through environmental analysis of residues and different leather production.

Activities:

As at the laboratory and semi-industrial trials, the environmental evaluation of the results of the pre-industrial tests has been done through the characterization of the effluents in accordance with international standards

Graph below shows the results of the characterization of residual baths from the bating/defatting, from the pickling/tanning stage and from the post-tanning stage from TRADELDA for calf and lamb and NEWPORT bovine:

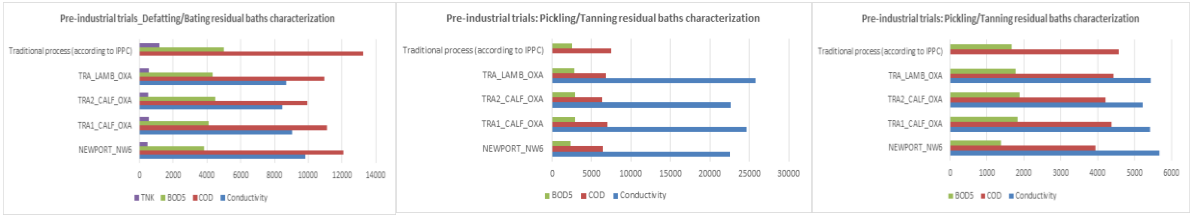

Figure 6.11. Analyses of residual baths from the bating/defatting, pickling/tanning stage and post-tanning stage

After the tanning process, leather samples processed by using natural products at the bating (POD), defatting (ECOD) and tanning (OXA) stages, were neutralized, retanned, undergone dyeing and fatliquoring in order to evaluate the behaviour of naturalised dyes and Ecofatting products on these leather samples.
Regarding the environmental impact of this technology, these trials confirm the higher environmental impact on wastewaters of traditional tanning process with respect to the natural tanning process developed in the LIFETAN project.
As they were processed according to LIFETAN tanning cycles, the following results are intrinsic:
- elimination (100%) of the presence of chlorinated molecules from the process in the degreasing phase, elimination (100%) of the chlorinated functional group in the tanning phase of the tanning cycle, with reduction of related toxicity,
- substitution (100%) of traditional recipes based on raw materials of petrochemical origin or toxic with new tanning formulations (Cr elimination),
- 100% reduction of Cr in wastewater, leather waste and dry sludge.

For wastewater: reduction (28-30%) of polluting load, reduction of TKN (from 52.1% for calf to 67% for lamb), and reduction of COD (from 10% bovine LTC 2 to 22% calf LTC4) for the whole tanning cycle, in comparison with traditional process (IPPC).

A detailed description of these tests and results is given in Del. B5/C4 “Tanning at a pre-industrial level by using natural products” and its Annexes, while some details about pollution reduction are presented in Del. C5 “Report on environmental benefit from LIFETAN cycle”.

6.1.11. Action C.5 Environmental benefits from the natural products tanning process

Objectives:

The aim of this action is to organize in a study all the information gathered from earlier actions, as well as results and conclusions, related to the comparison between leather products manufactured from natural products tanned hides and standard processed hides. This study contained photos of the leather products manufactured, and samples of natural products tanned hides at a semi-industrial and pre-industrial level.

Activities:

A planning of samples and parameters to be measured in order to obtain data to be used for Project performance Indicators has been agreed between all partners.
These additional data were used to verify if environmental impacts with natural products, at a pre-industrial level, are lower/comparable with Best Available Technique (BAT) or with Emerging techniques. This activity is preparatory to draft a report for IPPC bureau.
Regarding the environmental impact, the detailed description of environmental benefits is included in the Del. C5 "Report on environmental benefit from LIFETAN cycle".

The milestone "**Wastewater load reduction (20%); substitution of traditional recipes with natural formulations, with the overall chemical reduction**" was achieved for LIFETAN cycle 1-4. In fact, in order to facilitate the introduction of the new products in the tanneries, no changes were introduced in operating conditions, only chemical substitution. The overall results are summarized in the following table. The objective of chemical and toxic products substitution have been achieved.

Project results	Foreseen (at proposal)	Achieved (LIFETAN trials)
Alkyl phenol ethossilates	100%	100%
Synthetic chemical dyes	100%	100%
Chloroparaffins & sulphochloroparaffins elimination	100%	100%
Chlorinated functional group in the tanning phase of the tanning cycle elimination	100%	100% in defatting phase 0% in fattening phase
Improvement of chromium tanning exhaustion	Reduction of 20% of Cr salts	Reduction of 20% of chromium salts LTC 5
Improvement of chromium tanning exhaustion		Reduction 60% in LTC 3
Reduction of ammonium sulphate in the bating phase	60%	37.5% (2.5 % of ammonium sulphate at LIFETAN project versus 4.0% at traditional process)
COD reduction in wastewater	30%	9.8% – bovine 22.4% – calf 15.2% – lamb
NTK reduction in wastewater	30%	> 55 % calf, bovine, lamb
Improvement of wastewater biodegradability	---	AVERAGE 6.8
Less pollutants in bath wastewater, reduction of polluting in tannery wastewater	20 %	>28% bovine, calf, lamb
Chromium reduction in wastewater	100 %	100% LTC 1, 2, 4

Project results	Foreseen (at proposal)	Achieved (LIFETAN trials)
Chromium reduction in leather waste and dry sludge	100%	100% LTC 1, 2, 4
Increased penetration	50%	Verified -colour penetration in the whole section with natural products
Greenhouse gas emissions (kg CO2 eq/t raw leather) reduction in the bating phase	50	46%
Reduction of energy consumption	10	Saving in natural products manufacturing (PODEBA 60%, EDF20 and Cl-FAME 90%)

Table 6.9: Foreseen and achieved LIFETAN results

6.1.12. Action C.6 Quality assessment of leather products production

Objectives:

To control that the natural leather products production in the framework of the LIFETAN project (LIFE14 ENV/IT/000443) meet the quality standards required for leather articles manufacturing, as well as to compare their properties to those of products made from commercial products.

Activities:

The quality assessment of LIFETAN natural leathers through physical validations in accordance with accepted standards (EN, ISO, etc.).
For this, several physical validations were carried out to verify the quality of leather samples obtained at INESCOP, TRADELDA and NEWPORT, after the laboratory, semi-industrial and pre-industrial tanning processes conclude.

Reference	Tear strength (N)	Tensile strength (N/mm^2)	Elongation at break (%)	Shrinkage temperature (ºC)
Standard	UNE-EN ISO 3377-2:2016	UNE-EN ISO 3376:2016	UNE-EN ISO 3376:2016	UNE-EN ISO 3380:2016
NW6	185	38.6	56.4	76
NW6_SH	***162***	***32.4***	***48.2***	***75***
NW1000_6	196	42.6	68.3	78
NW1000_6_SH	***186***	***38.6***	***53.3***	***76***
TRA1_CALF	170	38.6	73.5	69
TRA1_CALF_SH	***169***	***33.3***	***68.7***	***69***
TRA1_LAMB	82	23.4	126.7	70
TRA1_LAMB_SH	***71***	***16.3***	***102.6***	***68***
TRA2_CALF	188	37.2	76.2	74
TRA2_CALF_SH	***178***	***34.3***	***72.6***	***73***
Recommended values	**> 70**	**> 15**	**> 40**	**> 65**

Table 6.10. Physical test in pre-industrial scale leathers

The physical test carried out on all leather types, in laboratory, semi and pre-industrial scale, show the compliance with the minimum recommended values for the manufacture of footwear and other leather articles (Example Table 6.10).
The detailed description of results is in the Del. C6 "Quality assessment of leather products production".

6.1.13. Action C.7 Monitoring of technical-socioeconomic assessment of the LIFETAN project

Objectives:

The demonstration of technical, social and economic viability of LIFETAN tanning cycle.

Activities:

The technical viability of LIFETAN tanning cycle was demonstrated with the combined use of the 5 natural/naturalized products. The cycle was not unique, but at least 4 cycles were developed and a fifth with Cr tanning, as reported in Figure 6.20. Cost analysis was carried out for Ltc 2 (Vegetale tinto in botte) for Newport and Ltc 4 (Finished leather) for Tradelda. LCA has been carried out for all the 4 cycles.

LIFETAN tanning cycles refer to four different tanning recipes, provided by Newport and Tradelda, they are reported with the name of the tannery, and the product obtained:

1. ***"Wet white vegetale***"- Newport (LIFETAN tanning cycle 1)
2. **"*Vegetale tinto in botte*"** -Newport – **(**LIFETAN tanning cycle 2)
3. "***Nabuk liscio***"- Newport (LIFETAN tanning cycle 3)
4. "***Finished leather***" - Tradelda (LIFETAN tanning cycle 4).

Regarding the environmental impact of this technology, these trials confirm the higher environmental impact on wastewaters of traditional tanning process with respect to the natural tanning process developed in the LIFETAN project.

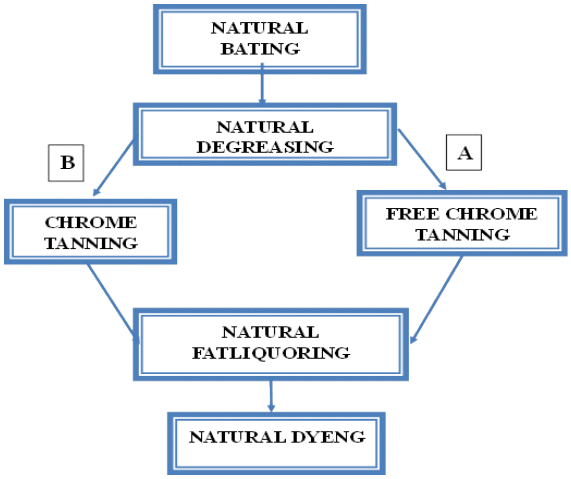

Figure 6.12. Diagram of the LIFETAN tanning cycles, expected and performed

In summary, the physical test carried out on all leather types show the compliance with the minimum recommended values for the manufacture of footwear and other leather articles.
The chemical validations carried out on all leather types show the compliance with the criteria of the European Eco-label for footwear (Decision 2002/231/EC).

- For economic viability 2 case studies
  - NEWPORT (bovine hides - cow bellies) cycle 2¸ selected because a new product ("raggrinzito effect") was obtained, with special characteristics;
  - TRADELDA (calf hides) cycle 4.

In fact bovine (calf, cow, …) hides represent about 90 % of tanning market.
Cost analysis for leather production in tanneries with LIFETAN products were carried out on the basis of: Data collections for LCA (formulations, recipes), Quantity of substitute products, Costs of substitute products the new products.
For LIFETAN products, the following prices have been assumed:

- EDF20 2.50 €/kg (average 2.2-3)
- PODEBA 1.00 €/kg (average 0.46-1.95)
- OXA 9.50 €/kg (in the market)
- ECOFATTING formulation 2.00 €/kg (average)

For Newport LIFETAN cycle 2, for the **beamhouse section**, there is a final increment of 1.58 €/100 kg raw hide, equal to an increase of 2.0% on standard tanning cycle to obtain crusts (not dyed). This reduced increase can be balanced by saving for wastewater treatments, reduced TKN (50%) and improved biodegradability.
These increments can be reduced or reversed with a change in scale production for natural products EDF20 and PODEBA.
A large cost difference is connected to tanning/retanning phase, because the dosage of OXA and Vegetable tannins is made before shaving in LIFETAN cycle; in this case the weight of pelts are still 95 kg, while then fattening and is carried out after shaving, on 60 kg.
It was obtained a new kind of leather ("raggrinzito" effect) special for some articles. Furthermore, the LIFETAN cycle 2 *allows obtaining free Chromium leather, with special characteristics. It can widen the light colours applications, which are not possible with Vegetable tanned leather and are possible only with Chromium tanned leather*.
As far as Tradelda, in the first part of the process the cost of Production with natural products LIFETAN is significantly lower than using commercial products used in the production of Wet White. However, analysing the economic cost of the subsequent retanning process for a colorless crust, it is clearly seen that it is a bit higher using NATURAL PRODUCTS and OXA than with the traditional Wet White products. In summary, the cost of process with LIFETAN NATURAL PRODUCTS compared with commercial products for the production of high quality footwear in Wet White with aldehydes and traditional retanning agents is very similar not more than 1-2 % difference.

Also **indirect economic benefits** have been explored, as consequences of direct environmental benefits connected with the use of LIFETAN products, referable mainly to:

i) Wastewater,
ii) Waste and Sludge, free from Chromium,
iii) Reduced use of chemicals, toxic or from no renewable sources (i.e. Ethoxilates and Chloroparaffins avoiding),

and in a larger scenario, waste prevention via poultry manure and lactose recycle and circular economy practices.

In the case of NEWPORT, indirect economic benefit can be connected to tariff reduction for wastewater discharge in a centralized wastewater plant. The tariff for each discharged m^3 is:

Tariff = C_{water} + C_{sludge}, where both C_{water} and C_{sludge} are function of COD and SS.

The LIFETAN product/processes application can induce COD reduction in wastewater and threshold exceeding prevention for some parameters (Chromium, sulphates). A decrease 10% of COD (as foreseen with LTC2) represents a saving of 0.13 €/m^3 wastewater, equivalent to 5.2 €/ton raw hides. The prevention of penalties for sulfates threshold exceeding represents saving of minimum 0.5 €/m^3 of all discharged water in the month.

In the case of comparison with a Cr tanning cycle, the major indirect economic (and environmental) saving comes from the prevention of waste and sludge with Cr (saving up to 8 and 10 €/ton raw hides respectively). These considerations can be extended to TRADELDA.

The introduction in the market of the new products, in the framework of LIFETAN Process, was based on the following pillars:

- **Customer Segments**

Haute couture producers
Test with natural/naturalized products to check special application (high ..)
Dialogues with high fashion firm or high quality producers are in progress or in construction

- **Value propositions: *Made in Italy, Ecolabel***

New natural and naturalized products in Italy
Know-how and Production in Europe: both products and leather
Compliance with Ecolabel for footwear

- **Natural products – manufacturers**

Also gradual scale up for production, starting from a unit production

- **Patent system**
- **IPPC submission as Emerging Technique**

Results obtained in the project organized in order to be included in Emerging Technique in BREF TAN

The project is also coherent with innovation and INDUSTRY 4.0 requirements, therefore with the innovations needed in tanning sectors.

The detailed description of results is given in the Del. C7 “Study of technical-economic-social viability”, and **Annex “LCA** document production and assessment of socio-economic impact”.

6.1.14. Action D.1 Website creation

During October 2015 the web site www.lifetan.eu was published and it is network-accessible in English, Italian and Spanish language. The site is periodically updated and it contains, in its public or reserved areas, all the documents produced during the project's activities, in particular:

- Link to LIFE+,
- Link to each beneficiary website;
- Results update;
- News update;
- Focus on;
- Reserved area;

ENEA was the responsible of the creation of the LIFETAN web site (Deliverable Action D1 "Website creation"). The project web site created is clearly and visibly marked with Life logo. In the Table are reported the monitored parameters at the end of the project.
Table Monitored parameters from January 2016 till December 2017

Also social network and newsletters were used to widen public and stakeholder involvement. In fact, the Official ENEA Facebook page (about 9.900 Like and 10.072 Follower), ENEA twitter (about 7.000 Like and 9.600 Follower) and INESCOP twitter (about 500 Like and 300 Follower) profiles were used for social network dissemination; a specific Facebook pages of the project was not created. The details are reported in the ANNEX titled "Public awareness and dissemination of results" attached to the Final report.

6.1.15. Action D.2 Innovative technology for leather industrial natural tanning manual

The LIFETAN manual, which explain in detail the now-how of the new leather natural techniques utilizing the LIFETAN innovative technology, was drafted and published before the end of the project. The LIFETAN manual content was edited by ENEA, in collaboration mainly with Newport and Tradelda that provided data and procedures and with the co-supervision of all beneficiaries. 1000 copies of the manual (24 pages) were printed by ENEA and sent:

- 200 copies to INESCOP
- 100 copies to Tradelda
- 150 copies to Newport
- 100 copies to CNR-ICCOM
- 10 copies to SSIP (Stazione Sperimentale per l'Industria delle Pelli e delle materie concianti, in Naples)

Figure 6.13 – LIFETAN manual

6.1.16. Action D.3 Training courses and workshops in Italy and Spain

Training activities in tanneries and workshops in tannery and tannery association centre on LIFETAN new technology were planned and organized as technical informative courses in in Italy and Spain, with special focus on protocols and procedures. The courses were specifically designed to train and form people of the trade (technicians and field workers) with a practical section for the application of the technique at a semi-industrial level. Technical informative courses were carried out in Italy and Spain as follow.

1. LIFETAN workshop in Valencia (Spain), 28th November 2017 (attendance of 115 participants) within ECOFIRA
2. LIFETAN workshop, ICCOM-CNR Pisa, 5th December 2017 (Italy) (participation of about 35 people)
3. LIFETAN Training course, Valencia (Spain) – 29th November 2017 (participation of 40 people of the tannery sector)
4. LIFETAN Training course, Santa Croce sull'Arno (Italy) – 19th December 2017 (participation of about 33 people of the tannery sector)

Foreseen 70 participants to workshops and 50 to training courses in the project indicators. Also, a student stage was carried out.

6.1.17. Action D.4 Diffusion material preparation

At the end of the LIFETAN project, all beneficiaries prepared various dissemination materials to be used in fairs, conferences, newsletters, etc, in particular:

- Logo definition and design performed. A LIFETAN logo was created for the project, to be shown on all dissemination documents of the project;
- ENEA created the structure of the project Notice Board and produced 15 LIFETAN Notice Boards, which were sent to all partners and displayed in visible spots and accessible places to the public on the partners' premises.
- 9 poster printed in more than 25 copies by all beneficiaries
- Project labels definition and design in order to identify leather samples and articles produced within the project, prepared mainly by INESCOP and NEWPORT;
- 1000 brochures, 6000 brochures and 3000 leaflets were prepared and printed in order to be ready for use in dissemination events
- 100 USB pen drives and 3000 sticky labels were produced as various branded items
- Since the beginning of the LIFETAN project, the following press releases and newsletter have been prepared for project dissemination, in the local, national and international press, TV interviews, specialised technical magazines, e-newsletters, etc.
- 25 papers web-printed
- 8 abstracts

Moreover, on the basis of the work carried out in before the end of LIFETAN project, other two articles were published at the beginning of 2018.

- Article in Arsutoria Magazine – English and Italian version
- Article in Avvenire 6 February 2018

Furthermore, more than news and information about LIFETAN projects reported on the web other, due to the diffusion of LIFETAN official articles, newsletters and communication on social networks (Facebook, Twitter).

The Layman's report was designed by ENEA with the support of an external company ((internetfly) for graphics and printing. The contents were defined with beneficiaries that collaborated also for the translation in Italian, English and Spanish languages. The PDF files of LIFETAN Layman's report (12 pages 100 copies of) were printed in 100 copies in Italian, English and Spanish languages.

Figure 6.14 – LIFETAN Brochure and Layman's report

The realization of the **LIFETAN project video** was performed by the Service communication and promotion of ENEA (ENEA REL-PROM). In particular, ENEA REL-PROM unit shot various scenes and video interviews in ENEA Faenza, CNR-ICCOM and Newport premises while INESCOP shot the scenes in INESCOP and TRADELDA premises, in March and November 2017. The predisposition and editing of the project LIFETAN video and of its preview was performed by ENEA REL-PROM. Dialogues and texts were defined by all beneficiaries.

LIFETAN samples books contained leather samples produced with the innovative LIFETAN technology were created for fair events and promotions, in order to allow visitors appreciate the leather materials tanned with the new natural products.
In particular were produced n.2 LIFETAN samples books by TRADELDA/INESCOP and n.2 LIFETAN samples books by NEWPORT.

Figure 6.15 – LIFETAN leather samples book

The details are reported in the Del. D4 "Diffusion Material Preparation".

6.1.18. Action D.5 International conferences, events and fairs

During all the project duration, LIFETAN project was presented to events, workshop, etc. or to public fairs, conferences, events externally organized, as foreseen in Action D5, in order to inform interested stakeholders about the project objectives, foreseen and obtained results.
At the end of the project, 25 events were attended, more than expected (6 events between international conferences and fairs).
In the Del. D4 "Diffusion Material Preparation" we show evidences of the participation to all the events with a specific characterisation and photos of each event.
The activities and results of LIFETAN were applied for SAPIO – INNOVAZIONE award in October 2017, with "Eco friendly tanning cycle)".

Figure 6.16: Tradelda stand at Lineapelle October 2017

6.1.19. Action D.6 Networking

The creation of an active network which facilitates the exchange of information among consortia that work or have worked in the past on topics related to the project was expected. A number of 10 projects or initiatives connected with LIFETAN project's was expected, while at the end of the LIFETAN project 13 projects have been connected and 12 networking initiatives were realized.
During the LIFETAN project, all the project beneficiaries were responsible of the following networking activities and have presented the project in different national and networking events. Detailed lists of LIFE project networking and Cluster following LIFE project are reported in the Dissemination Annex. Moreover, detailed list of the networking events is reported in Table 5.1 of the Dissemination Annex.

Figure 6.17: ENEA at SSIP in Naples (Italy), October 2017

6.1.20. Action E.1 Project management

The project coordination activities need daily work, to maintain a permanent flow of action with the aim of achieving the objectives set. The actions carried out were:

- Preparation of the Partnership Agreement;
- ENEA participation to KoM of LIFE14/ENV in Brussels (27th October 2015)
- Coordination and monitoring meetings
- Organisation of different meetings between some partners, to plan and monitor the project technical activities;
- Continuous contact between all project partners for monitoring project activities;
- Preparation of material for meetings;
- General actions and activities for the coordination of the project;
- Management of the financial aspects of the project;
- Monthly reports to the LIFE external team monitor on the evolution of the project.

During this period, the associated beneficiaries, ICCOMCNR, Newport, Tradelda and INESCOP participated in project management activities, keeping in smooth contact with the project coordinator. In this sense, they prepared and attended the project management meetings and collaborated with the project coordinator (ENEA) in the preparation of this Final Report, as set out in the project proposal.

Project beneficiaries have carried out different meetings in order to organize, coordinate, monitor and develop the project. The following coordination and monitoring meetings were organized:

- Coordination meetings:
  - Kick-off meeting, 22th October 2015, at the associated beneficiary ICCOM-CNR premises in Area della Ricerca CNR, Pisa- Italy.
  - Progress and Coordination 6 month meeting, 21st April 2016, at the coordinating beneficiary ENEA premises in Faenza - Italy.
  - Progress and Coordination 12 month meeting, 18th October 2016, at the associated beneficiary Newport premises in S. Croce sull'Arno Pisa - Italy
  - Progress and Coordination 24 month meeting, 18th October 2017, at the associated beneficiary Inescop premises in Elda – Spain.
- Monitoring meetings with LIFE's External Assistance Team:
  - Monitoring meeting, 7th June 2016, at the coordinating beneficiary ENEA premises in Faenza - Italy: with Project Monitor.
  - Monitoring meeting, 26th-27th April 2017, at the coordinating beneficiary Newport premises in S. Croce sull'Arno Pisa - Italy: with Project Monitor and EASME Project Advisor.
  - Monitoring meeting, 22nd November 2017, at the coordinating beneficiary Newport premises in S. Croce sull'Arno Pisa - Italy: with Project Monitor.

In addition many phone and web meetings between some partners were organised in order to plan and monitor the project technical activities.

6.1.21. Action E.2 Monitoring

During the whole period of the LIFETAN project, monitoring tasks have been carried out for each action, in particular:

- ENEA used project progress indicators for monitoring project activities;
- ENEA revised the project progress indicators in each of the projects coordination meeting in order to check any irregularities;
- ENEA has been checking the number and type of people reached by each dissemination activity, to check whether the diffusion actions have met their goals;
- ENEA, as project coordinator, had continuous contact with all project partners for monitoring project activities;
- ENEA, as project coordinator, prepared and sent a monthly indication of operative activities to be done to all the partners;
- ENEA, as project coordinator, prepared and sent a monthly summary of the project activities to the monitoring representative and to all the partners

6.1.22. E.4 After-LIFE Communication Plan

The present After-LIFE Communication plan is aimed at ensuring that the project LIFETAN will be subjected to a large and widespread dissemination even after the official date of completion of the project. This plan is set out to continue the dissemination and communication of the project and its results.
This dissemination will be aimed as much at a European level as a global level, given that close contact that ENEA and INESCOP maintain with various institutions all over the world.
The dissemination will continue to SMEs mainly through ENEA and INESCOP through website, conferences, fairs, relationships with other EU RTD Centres, and with leather Centers in Third Countries, and to general public.
ENEA, as coordinator with all beneficiaries' contribution, has prepared a **toolkit** for LIFETAN results dissemination constituted by:

- Layman's Report,
- Brochure,
- LIFETAN Manual,
- together with availability of video,

which have been distributed to all beneficiaries by the end of the project and are useful for the dissemination of results in fairs, conference, training courses or presentation to clients.
The detailed description of the After-LIFE communication plan is reported in the Deliverable E4 "After-LIFE communication plan" in English, Italian and Spanish. A summary of planned dissemination activities with the estimation of related costs are contained in following Table 6.11.

Activity	*Responsible*	*Duration after the project end*
Website update	ENEA	3 years
Dissemination in FAIRS events linked to Environment and leather sectors, in particular in 2018-2019:	All beneficiaries	5 years
Dissemination in Conferences linked to Environment and leather sectors, in particular in 2018-2019:	All beneficiaries	5 years
Dissemination by general and specialized press.	ENEA and all beneficiaries	5 years
Publication of one or two scientific papers	ENEA and all beneficiaries	5 years
Demonstration & Training Actions	INESCOP	
Networking with H2020 and LIFE projects related to tanning cycle, natural products, circular economy	All beneficiaries	5 years
Distribution of dissemination toolkit during special events, workshops, direct visit and meeting	All beneficiaries	5 years
Development and New contacts with stakeholders in Italy and Spain	All beneficiaries	5 years
Development of contacts already initiated with stakeholders, Institutions and policy makers:	All beneficiaries	5 years
Contribute to EC policy via LIFETAN Emerging Technique submission.	ENEA and all beneficiaries	2 years

Table 6.11. Planned dissemination activities foreseen after LIFETAN completion

6.2. Main deviations, problems and corrective actions implemented

Technical activities, particularly in tanneries, allowed identifying not a LIFETAN tanning cycle, but more scenarios were possible with natural/naturalized product combination. In order to demonstrate the environmental advantages and the sustainability of the LIFETAN processes and to disseminate them and propose as ET (emerging Tecnique), more months activities were needed and so a project duration extension of 3 months, from September 30th to December 31st, 2017 was asked and granted.

6.3. Evaluation of Project Implementation

The project coordination actions needed daily work to maintain a permanent flow of action with the aim of achieving the objectives set. The actions carried out were:

- Preparation of the Partnership Agreement
- Participation to KoM of LIFE14/ENV in Brussels
- 4 Coordination meetings
- 3 Monitoring meeting
- Organisation of different phone and web meetings between some partners in order to plan and monitor the project technical activities
- Continuous contact between all project partners for monitoring project activities
- General actions and activities for the coordination of the project.
- Management of the financial aspects of the project.
- Monthly reports to the LIFE external team monitor on the evolution of the project.

- ENEA, as project coordinator, prepared and sent a monthly indication of operative activities to be done to all the partners.
- ENEA, as project coordinator, prepared and sent a monthly summary of the project activities carried out to monitoring team and to all the partners.

The following table compares through quantitative and qualitative information the results achieved at the end of the LIFETAN project against the objectives of the proposal. It is clearly evident that the work carried out during all the LIFETAN project was perfectly in line with was expected in the LIFETAN proposal.

Action	Foreseen in the revised proposal	Achieved	Evaluation
B.1 Demonstration of the use of the different toxic and chemical products currently used in the EU tanneries B6	Definition of the toxic products in the tanning process at the bating, defatting, tanning, fatting and dyeing stages in order to evaluate which products should be removed from the tanning process formulations and to find information on potential natural substitutes less dangerous and polluting.	✓	Deliverable B1: Definition of the main environmental impact and hazardous substances in the tanning process at the bating, defatting, tanning, fatting and dyeing stages: - Enzymatic products - Alkylphenol and alkylphenol ethoxilates - Chromium salts/ Chromium VI - Azocolorants and azodyes and Acid dyes mixed with surfactants, dispersing agents, paraffin, inorganic salts, etc. - Chlorinated paraffins short chain (C10-C13)
B.2 Demonstration of natural products	Definition of natural based products and processes for bating defatting, tanning, dyeing and fatting phases and evaluation of their interactions with leather and their compatibility for their simultaneous use in the process	✓	Demonstration of properties and interactions between each natural product and collagen fibres of leather and its compatibility. Production of natural/naturalized products a total of 90 kg, except Oxazolidine (commercial). Definition of production under REACH registration threshold: - 20 t/y of EDF20, -5 t/y of Fatliquoring agent.
B.3 Demonstration of natural products in the whole tanning cycle at laboratory level	Definition of LIFETAN tanning formulations Laboratory level trials by comparing commercial and natural bating agents and its influence in the chrome tanning process Laboratory level trials comparing several combinations of commercial and natural bating, defatting and tanning agents, evaluating its environmental impact and the quality of the leather obtained.	✓	Deliverable B3/C2: the demonstration of the reduction of the chrome tanning demand by using the natural product (LHM) in the bating phase and the compatibility of the simultaneous use of natural bating, defatting and tanning agent obtained. - 20% Cr salts reduction in tanning stage with the use of Podeba bating agent and EDF20. - 8 tests with comparison of commercial and natural products.
B.4 Tanning at a semi-industrial level by using natural products	Different types of hides at a semi-industrial level underwent complete tanning cycle using natural products alongside toxic and chemical products. - 50 sheep/goat skins leathers tanned with the use of the project natural products in the tanning	✓	Newport tests on bovine hides to define their procedure for PODEBA and OXA use. Lamb skins and calf hides tanned by INESCOP, comparing Cr and (OXA+Veg) tanning: use of all the other 4 natural/naturalized products. - 40 sheep skins tanned with natural

Action	Foreseen in the revised proposal	Achieved	Evaluation
	phase. - 50 cattle/calf skins leathers tanned with the use of the project natural products in the tanning phase.		products, - 20 calf hides + 50 bovine hides tanned with natural products.
B.5 Demonstration of natural products tanning at a pre-industrial level	Different types of hides at a pre-industrial level underwent complete tanning cycle using natural products alongside toxic and chemical products. - 50 sheep/goat skins leathers tanned with the use of the LIFETAN natural products in the tanning cycle - 50 bovine hides leathers tanned with the use of the LIFETAN natural products in the tanning cycle.	✓	4 sets of pre-industrial tests were carried out in industrial drums: - Newport (200 kg + 1700 kg of bovine hides – 285 bellies), - Tradelda (200 kg calf hides, 200 kg lamb skins + 1000 kg of calf hides) with the different LIFETAN tanning cycle - INESCOP 15 pig skins. Produced more than 300 bovine leathers with LIFETAN cycles (4 recipes) and 50 sheep/goat leathers + pig skins
B.6 Leather products obtained with the use of natural products for the tanning cycle	- Production of 100 different types of leather products - Validations of harmful substances in hides based on international standards.	✓	- Production of 75 shoes pair in Spain (50) and Italy (25), production of 7 bags and 18 items (wallets, key holders) and garments - Validations that all LIFETAN leather had chemical concentrations low so as to comply with limits of ECOLABEL for footwear.
C.1 Monitoring of the toxic and chemical products environmental impact	Evaluate the environmental impact of traditional products in the residual baths of each problematical stage: bating, defatting, tanning, dyeing and fatliquoring.	✓	Analysis of the environmental impact of the different tanning agents most used by European tanneries, in order to be able to compare them with the impact of the proposed natural products
C.2 Environmental monitoring of tanning with natural products at laboratory level	Evaluate the environmental impact and the quality of the leather obtained in the laboratory level trials (Action B.3) of several combinations of commercial and natural bating, defatting and tanning agents, in order to compare the behaviour of natural products and commercial products.	✓	Environmental impact and leather quality tested by means of the characterisation of the waste-baths and leathers obtained in the different tests carried out, determining the most significant parameters in accordance with international standards. Wastewater characterization: 3 stages, Bating/defatting, pickling/tanning, post-tanning. Reduced TKN, biodegradability increased in each stage with natural products. Leather quality was appropriate and all data were coherent with expected results: physical properties in C6, chemical characterization in B6.
C.3 Environmental monitoring of tanning with natural products at semi-industrial level	Evaluate the environmental impact and the quality of the leather obtained in the semi-industrial level trials (Action B.4) of several combinations of commercial and natural bating, defatting and tanning agents, in order to compare the behaviour of natural products and commercial	✓	Wastewater characterization: 3 stages, Bating/defatting, pickling/tanning, post-tanning. Reduced TKN, biodegradability increased in each stage with natural products. Results improved in comparison with laboratory level. Leather quality was appropriate and all data were coherent with expected

Action	Foreseen in the revised proposal	Achieved	Evaluation
	products.		results: physical properties in C6, chemical characterization in B6.
C.4 Environmental monitoring of tanning with natural products at the pre-industrial level	Evaluate the environmental impact and the quality of the leather obtained in the pre-industrial level trials (Action B.5) of several combinations of commercial and natural bating, defatting and tanning agents, in order to compare the behaviour of natural products and commercial products.	✓	Wastewater characterization: 3 stages, Bating/defatting, pickling/tanning, post-tanning. Reduced TKN, biodegradability increased in each stage with natural products. Results improved in comparison with laboratory level. Leather quality was appropriate and all data were coherent with expected results: physical properties in C6, chemical characterization in B6.
C.5 Environmental benefits from the natural products tanning process	Report on environmental benefits from LIFETAN cycle: water saving, wastewater load reduction, and substitution of traditional recipes with natural formulations, with the overall chemical reduction	✓	Expected results confirmed: - 100% elimination Alkyl phenol ethoxylates, Synthetic chemical dyes, Chloroparaffins & sulphochloroparaffins. - 30% reduction Cr salts, - 50-60% reduction ammonium sulphate, - in wastewater reduction 16% COD, > 50% NTK, 100% CrIII, Biodegradability increase. - 100% elimination Chromium reduction in leather waste and dry sludge No water saving: too difficult to introduce in tannery expertise
C.6 Quality assessment of leather products production	Physical validation of natural products manufactured in action B6 in compliance with international standards to check they have characteristics at least equal to standard leather products and in compliance with regulations	✓	Physical validations of all kind of leathers produced with natural/naturalized products at laboratory, semi and pre-industrial scale was carried out. All in compliance with the limits required for footwear or other leather articles manufacture. Tg (68 and 76 ºC) good for a Cr free leather.
C.7 Monitoring of technical-socioeconomic assessment of the LIFETAN project	Proof of Quality and LCA document with the elaboration and analysis of project data in terms of socioeconomic impact of the project naturalised tanning process.	✓	Technical and environmental viability of 4 LIFETAN tanning cycle, at least, tailored on tannery expertise, with the use of the equipment and drum already present in tanneries. LCA for 4 LIFETAN cycles. Economic assessment: for EDF20 with PODEBA about 1-2% increase on the total tanning costs, balanced by wastewater biodegradability. The need is the introduction in a market niche, where costs 20% higher are acceptable. 2 practices of circular economy Wastewater biodegradability data shown important interaction between EDF20 and Podeba bating agent (application of Minitab software)

Action	Foreseen in the revised proposal	Achieved	Evaluation
D.1 Website creation	Project web site	✓	Project web site continuously updated Individual directly with website 2446/8000, larger number via social network (ENEA Facebook page/twitter, 10,000 follower)
D.2 Innovative technology for leather industrial natural tanning manual	1,000 copies of the LIFETAN manual	✓	1,000 copies of the LIFETAN manual and distributed 200 INESCOP 100 Tradelda 150 Newport 100 ICCOM-CNR 100 SSIP (Stazione Sperimentale Industria Pelli e Materie concianti)
D.3 Training courses and workshops in Italy and Spain	- 2 training courses hosted and run: 1 by NEWPORT in their Italian facilities and 1 by INESCOP and TRADELDA in their Spanish facilities. - 2 workshops were held: 1 in the Italian Newport facilities and 1 in the Spanish TRADELDA and INESCOP facilities.	✓	• 2 training courses in NEWPORT (33 participants) and in the premises of Confederacion Empresaria Valenciana -Valencia by INESCOP and TRADELDA (40 participants). • 2 workshops: 1 in CNR premises in Pisa (35 participants), 1 within ECOFIRA in Spain (115 participants, 34 registered)
D.4 Diffusion material preparation	• 25 Posters • 10 Notice boards • 10,000 leaflets/brochures/factsheets • 2,500 various branded items • 30 publications on different media • Layman's report • Project video • 4 sample books of LIFETAN leather samples	✓	• Logo • 10 LIFETAN Notice Boards (15 copies) • 1000 (brochures) + 6000 (brochures) + 3000 (leaflets) leaflets • 100 USB pendrive + labels + 3000 sticky labels • 25 published print/web +8 abstract • 9 posters in more than 25 copies/ • Layman's report (It, Eng, Es) • Project video • 4 sample books of LIFETAN leather samples (2 by Newport , 2 Tradelda)
D.5 International conferences, events and fairs	participation at minimum 6 events between international conferences and fairs	✓	participation at 25 events and fairs
D.6 Networking	Clusters with 10 projects	✓	Clusters with 13 projects and 12 networking initiatives were realized also with stakeholders
E.1 Project management	Management of project activities	✓	Continuous contact between all project partners and project meetings
E.2 Project monitoring	Monitoring of project activities	✓	monthly indication of operative activities and monthly summary of the project activities
E.4 After-LIFE Communication Plan	LIFETAN After-LIFE Communication Plan	✓	Proposal presented in English, Italian and Spanish

6.4. Analysis of benefits

1. Environmental benefits

Leather represents an example of by-product valorisation, dealing with the transformation of hides and skins, food industry by-products, into useful products for mankind (garments, upholstery, shoes, …). In 99,5% of cases, the hide is a co-product of the food industry, instead of being disposed of as waste, is enhanced and transformed by the manufacturing industry in a durable product and value (UNIC, 2017). In the same way, the transformation of egg by-products (poultry dejections) into technical products to be used in leather chain can be a valid alternative to the use as fertilizer but also prevent problems concerning their disposal in areas where poultry rearing are concentrated and manure production exceeds agricultural soil receptivity. The same considerations can be made for the use of lactose, a by-product from milk serum processing of the dairy industry that is used to produce naturalized dyes and defatting agents for tanning; in this way it is possible to reduce whey disposal.
The leather sector is a "heavy impact" one and a large consumer of sources: for 1 ton of initial hides/skins more than 400 kg of reagents/additives are needed to produce 200-250 kg of leather. About 20-25 % of raw (salted) bovine hide weight is transformed into leather; for sheep or goat skins, this range is 12-15 %, based on salted raw skins. When sole leather is produced, the proportion is approximately 65% (BREF TAN, 2013).

The LIFETAN project is developed on the basis of 5 different LIFE projects, each of them substituting chemicals with natural or naturalized products (with chemicals obtained from natural products) in a distinct phase of tanning process:

- PODEBA, with the substitution of enzymes and ammonium sulphate with treated and deodorized poultry manure (PODEBA bating agent) in bating phase,
- ECODEFATTING, with the reduction of ethoxylated derivatives with lactose derivative compounds in defatting phase,
- OXATAN, with the complete substitution of Chromium salts with oxazolidine, saturated heterocyclic compounds prepared by reacting primary amino alcohols with formaldehyde, in tanning phase,
- ECOFATTING, with the substitution of Chloroparaffins with products based on palm kernel oil in the fatting phase,
- BIONAD, with the substitution of commercial with naturalized dyes based on the use of the sugar lactose, in the dyeing phase.

a. **Direct / quantitative environmental benefits**:

As a result, LIFETAN laboratory, semi-industrial and industrial tests have demonstrated the achievement of the following results, in agreement with KPI (see cap.7):

- substitution (100%) Alkyl phenol ethoxylates, Synthetic chemical dyes, Chloroparaffins & sulphochloroparaffins;
- 35-40% reduction ammonium sulphate at deliming-bating stage;
- in wastewater reduction 16% COD (average for calf), > 50% NTK, 100% Cr III, Biodegradability increase,
- 100% elimination Chromium in leather waste and dry sludge;
- of traditional recipes based on raw materials of petrochemical origin with new tanning formulations, based also on lactose derivatives;
- innovative use of the poultry dejection in the bating phase in the tanning cycle;
- demonstration of the technical-financial feasibility of chrome-free leather tannage using oxazolidine;

- demonstration of (20%) reduction of Chromium salts in tanning with natural/naturalized products and Cr tanning.

b. Qualitative environmental benefits

The technological sustainability of LIFETAN in the long term is linked to some fundamental aspects:

- the sustainability of the natural or naturalized products would be guaranteed by renewable sources and by the implementation of further technological improvements;
- the use of by-products in some cases (poultry manure as by-products of egg production for bating agent and lactose as byproduct from milk serum processing of the dairy industry for defatting agent and dyes) reduces waste production and induces circular economy practice, also industrial symbiosis examples;
- the use of natural substances improves wastewater biodegradability, contributing to the planning of preventive measures for the improvement of the environment;
- the production of leather with high added value;
- the strategy of industrial implementation of actual handcraft products and their use in tanneries.

LIFETAN aims at drawing a better quality bating, defatting, fattening, dyeing phases, applying little modifications to the current tannery processing.

The improvement of wastewater biodegradability adds value to the design of preventive measures for the benefit of the environment and humans' health, emphasizing the solutions that the legislator and the parties involved in the business can put in place. Referring to document EEA 2013/84/EU,[3] the regulations about the quality of wastewaters and the reduction of mains water consumption would encourage the creation of new joint ventures, to connect tanneries and operators involved in waste disposal. This would lead to general improvements for the eco-compatibility and eco-sustainability themes, associated to specific industrial business such as that of the leather sector.

Probably, the biomass produced by the treatment of tannery wastewater in the LIFETAN process could also receive a feedback about environmental policies from other productive sectors such as agriculture. The agronomic reuse of sludge can be a viable solution to its disposal and arouse considerable interest as an alternative fertilizer.

2. Economic benefits.

Italy confirmed its economic supremacy in the tanning industry, both in terms of quality and production value (with a share of 66% of the total European and 17% worldwide) and on the international level (incidence of 30% overall on exports of finished leather). Italy and Spain represents >80% European sector. Historically the industry is mainly composed of small and medium enterprises. It is a growing sector linked to quality (i.e. *made in Italy*), product certification and environmental sustainability (UNIC 2017).

Long term economic benefits of the technology were demonstrated (see Deliverable Action C7 "Monitoring of technical-socio-economic assessment of LIFETAN project"), taking into consideration the production chain, with the different subjects:

- manufacturers of natural and naturalized products,
- tanneries (end user),
- producer of leather goods.

[3] COMMISSION IMPLEMENTING DECISION of 11 February 2013 establishing the best available techniques (BAT) conclusions under Directive 2010/75/EU of the European Parliament and of the Council on industrial emissions for the tanning of hides and skins [notified under document C(2013) 618].

In the project, natural/naturalized prices vary as a function of production scale. Globally, the natural products have costs a little higher than standard products, with an incidence of tanning costs quite low (+ 1-2%) with the maintenance of the quality of the leathers produced. This extra-cost can be balanced by saving in waste and effluent management thanks to the lower environmental impact of wastewater. Furthermore, the natural product cost can be reduced by increasing the potentiality of their plant manufacturing.
In addition, leathers with new characteristics ("raggrinzito" effect) have been produced in LIFETAN project confirming the beneficial effects of the natural products in terms of quality. In any case the exploitation of the project results could be addressed towards a high quality market where a slight higher price could be better accepted.
The LIFETAN project can also lead to the creation of new jobs for the production of the new natural and naturalized products for leather production. This could also be a driving force to introduce qualified workers in the "green chemistry" industrial sector to produce for example naturalized dyes for textile sector.

3. Social benefits.

About social aspects, we can presume/assume:

- there are no changes in plants and no changes in jobs (number and mansion) in tanning sector;
- there could be an expansion in an "ecofriendly market", with leather treated with more natural or naturalized products and with a higher social value and price;
- the wastewater characteristics showed an improvement in terms of biodegradability, which implies a lower impact of the waste generated in the tanning process, including sludge;
- use of renewable resources from vegetables and use of by-products (poultry manure and lactose), saving resources from oil (chemical compounds, such as paraffins, ethoxylates derivatives and mineral fertilizers);
- the use of chemicals based on natural products (green chemistry, biorefinery) introduce practice of circular economy.

New product objective is to improve environmental performance maintaining employment in leather sector, because of less environmental conflicts and resource saving.

4. Replicability, transferability, cooperation: Potential for technical and commercial application

This is a complex project, with 5 new products, one already at commercial stage (oxazolidine) and the other 4 at handcraft level production, demonstrated at kg scale along LIFETAN. The natural or naturalized product manufacturers, beneficiaries of previous projects, were the supplier of the LIFETAN project.
The application proceeded alongside with:

- the choice of tanners to upgrade their daily operations with natural products. Economic driver was vital, both as saving in production and increase of final leather product revenue, because of quality or trademark or special mark for environmental benefits of the new solution;
- the industrial production of a new class of products (natural and naturalized ones), the choice of the producers to invest in these products. Industrial development of lactose derivative for the productions of defatting agents and naturalized dyes was necessary. Natural bating agent is potentially "ready for the market" and its transferability to industrial scale is connected to DPM/PODEBA bating agent industrial production;
- the constrains related to R.E.A.C.H. registration have been investigated, it is possible to produce (under threshold):

- 20 t/y of EDF20, corresponding to 1 t/y of product derived from lactose,
- 5 t/y of Fatliquoring agent, corresponding to 1 t/y of CL-FAME product.

The replicability and transferability of the eco-friendly LIFETAN tanning process is favourite by the presence as beneficiaries of two industrial tanneries in the project, which do not know all the new products and test them in their own process and plants. Consequently, by performing application at semi-industrial and pre-industrial level, they can observe difficulties, drawbacks and positive effects and transmit the experience to tannery sector, with the support of technical and scientific competence of other beneficiaries. Training course and workshops had this goal. INESCOP has a key role in traducing innovation in leather sector.
In addition, these results could directly be diffused in Italian leather districts and shoe section in Spain (Spanish and Italian market represent almost 90% of EU market), but also in international (Asian and South America) market as an innovative proposal to combine economic saving with eco-friendly lines. LIFE project is essential to gather the beneficiary group and to have the "power" and "visibility" for market entry.

Other opportunities are represented by:
- dialogue with leather producers of high fashion sector and/or of high quality leathers able to use small quantities for high level production and consequently accept an initial higher price.
- preservation or improvement of industrial districts (e.g. Arzignano, S. Croce sull'Arno and Solofra in Italy and the region of Catalonia, Valencia and Murcia in Spain),
- cooperation with SSIP (Stazione Sperimentale per l'Industria delle Pelli e delle Materie Concianti srl) in the framework of **Progetto RAIDto4.0 – Task ScoPro**.

Finally, the program can be an instrument to introduce the results of LIFETAN in other companies, and demonstrate that the use of the new natural/ized products in tanning cycle are compatible with **Industry 4.0** strategy, and within new tanning cycle, also using different technique (no salted raw hides).

5. Best Practice lessons.

The aim is to propose an update of tanning technique with natural products, on the basis of best practice for bating phase used by beneficiaries for project development. The new natural products do not affect work organization/operating and best practice, favouring their introduction on the market and use.
We can proceed in this way:

- Comparison of the data produced in LIFETAN with present reference technique (BAT) for the different phases of tanning process.
- proposal of PODEBA results, confirmed also in the framework of LIFETAN, as Emerging Technique (ET) – Natural bating agent, to IPPC technical group.
- Future third step to present the results at least of LIFETAN beamhouse section (Podeba bating agent + EDF20) and/or the whole eco-friendly tanning technique for emerging technique or BAT in leather sector.

6. Innovation and demonstration value.

LIFETAN represents product innovation and process innovation. Innovations are natural and naturalized products, characterized by the handcraft production, which are well performing in their single use. Innovation is ecofriendly tanning process, with integration of natural(ized) in order to obtain leather quality. Innovation is the use of bating agent which can reduce Cr salts in tanning by 20%.

It is therefore a product innovation coherent with observations in BREF TAN (2013), where it is noticed that "innovations in leather industry related to environmental performance are usually focused on chemicals rather than on machines".

LIFETAN project is the demonstration phase of an integrated naturalized tanning cycle, needed in order to produce a performance framework, a scientific reference, high visibility results. Results are in terms of:

- containment of environmental impact,
- resource saving,
- by-products recovery and recycling, within practice of circular economy and industrial symbiosis.

The demonstration is carried out taking into reference standard process conditions, just substituting standard formulates with new natural products. These assumptions were agreed at the beginning of the project in order to facilitate the introduction of the new products, also in presence of a high variability of the tanning processes, often an artisanal know-how and without equipment changes.

As described in previous paragraphs, the LIFETAN processes based on the use of natural/naturalized products developed in previous LIFE projects PODEBA, ECODEFATTING, OXATAN, ECOFATTING & BIONAD have successfully been applied both to calf/bovine hides and sheep skins, as far as pig skins.

This demonstration was based on:

- physical and chemical characterizations of final leathers (quality assessment of leather products, Deliverable C6),
- environmental impact, particularly wastewater characterizations (Deliverable C5). In this case there is a little differences between application of LIFETAN process to lamb and calf, only a few % (less reduction COD, major reduction TKN for lamb in comparison with calf).

Different tanning cycles have been developed, but particularly two have been investigated:

- LIFETAN Tanning Cycle 2, by NEWPORT,
- LIFETAN Tanning Cycle 4, by TRADELDA.

Both cycles chromium free showed very interesting features leading to final products having particular properties.

LTC 2 leathers showed a "raggrinzito effect" of the grain side, not foreseen and not highlighted in the chrome tanning. After special surface treatment, these peculiarities made them a special feature.

The product obtained has particular characteristics and, after an initial check, doesn't present any physical problem. The characteristics of this product obtained are optically of a "raggrinzito" leather, intermediate between a vegetable tanned leather with a coat and fluency of a chrome leather but free of that product. The crust color varies the classic colour of the vegetable in a yellow brown colour with more opaque tones (Deliverable B5/C4).

LTC 4 demonstrated a very wide potentiality, with application to shoes, bags, "traforato" leathers.

LTC 3, with reduced Cr use, was applied to produce leathers for shoes manufacturing.

From a general point of view, the well-known weaknesses, the critical issues of a non-chrome tanning leather are:

a. connected to final leather processes, a leather final structure which cannot be folded up to produce pointed shoes without seeing cracks, dryness,
b. connected to color: final leather exposed to the sun modifies the colour (as our skin changes color when we are exposed to sun, the same for a natural product).
c. connected to color, it is not possible to produce light color leathers with tannins and therefore the range of available colors is restricted.

As far as point a, LIFETAN final leathers (LTC 2 and 4) showed physical characterizations (tear - tensile strength, elongation at break) which afford the possibility to manufacture shoes, also pointed shoes. LTC4 calf leathers were used to produce pointed boots. Shrinkage temperature for calf reaches 73-74°C, higher than 65°C requested from standard and higher than 50-55°C of Vegetable tanning.
Therefore these aspects have to be deepen, but it is possible to tackle them. Certain kind of shoes can be manufactured only with a Cr tanning, but they could be produced with LTC 3 calf leathers.
As far as point b, it could be possible to turn a weakness into a virtue, from a commercial point of view. In fact the possibility to have a bag which modify its colour is a signal that this a natural product, it is a sort of intrinsic assurance, it is a specific characteristics. Therefore, point b is not modifiable, but it can be highlighted as positive characteristics from commercial point of view.
As far as point c, LIFETAN tanning cycles can produce leather with very light colours and tones, not white, but really widening the range of color for leathers not Cr tanned. However, LIFETAN actual processes exclude white colors and very bright colours, even fluorescent ones.
A further point to be highlighted for LIFETAN leathers is the possibility to produce "traforato leathers", very appreciated by fashion. Backpacks with some perforated parts were produced. Aspects connected to yields, kind of holes have to be investigated, but are promising.
The international partnership project helps to introduce innovation in tanning sector; the involvement of Italian and Spanish beneficiaries covers almost 80% of EU capacities.

7. Policy implications: *Indicate any important achieved targets contributing to the future implementation, design or take-up of regional, national or European legislation. Please highlight any potential unintended impacts, bottlenecks or barriers to the implementation of your project due to regional, national or European legislation including recommended actions further to actions already taken to overcome these barriers.*

The impacts of the leather industry are well-known, as the treatment of animal hides and skins involves the use of large amounts of chemicals and volumes of water, generating significant pollution loads. For this reason several initiatives have been undertaken at international level.
LIFETAN is coherent with EU policies for environmentally significant issues or policy areas, such as the 6th and 7th EU Environment Action Programmes (Decision No 1600/2002/EC and No 1386/2013/EC) whose objectives are the health and quality of life, the environment and the management of resources towards sustainable production models. The project goes into this direction, exploiting its own potential in terms of new eco-friendly technologies and trying to spread these innovations publicly, that may help in drawing up the drafts of EU policies to limit the pressure on natural resources. It is important to highlight that the development of LIFETAN project supported the application of the Environmental Technologies Action Plan (ETAP), whose objective is to further environmental technologies to improve the environment and European competitiveness supporting eco-friendly technologies since they are good for business, reduce pressure on the environment and can create new jobs. Examples are treatment of waste for reuse or recycling, such as the production of natural or naturalized products for bating, defatting and dying phases. ETAP has among its high-priority actions getting from research to markets actions, improving the innovation process and moving invention from laboratories to the market, and improving market conditions aiming at encouraging the market uptake of environmental technologies.

The development of natural or naturalized products and processes is coherent with Horizon 2020 strategies.
For the Europe's tanning industry the main environmental regulations are the EU Directive (2010/75/EU) on industrial emissions (integrated pollution prevention and control) (Recast), "Waste" Directive (2008/98/EC & s.m.), the Water Framework Directive (2000/60/EC), the legislation on animal by-products (Reg. 2009/1069/EC, 2011/142/EC) and the R.E.A.CH. Regulation (2006/1907/EC).
The guidance towards natural(ized) products was the innovative policy about the production, use and trade of chemical substances under the acronym of R.E.A.CH., which confers direct responsibility to producers, traders and even consumers for the control and monitoring of the chemical substances within the EU. The use of "lactose" from waste milk serum to generate naturalised dyes or defatting agents, impacting heavily on the disposal of this highly hypertrophic substance, the use of the innovative oxazolidine (chrome-free) tanning technology, in view of industrial production, would reduce energy and waste management costs for the whole chain. Both the presence of lactose and the reduced amount of ethoxylated derivatives in the new products would allow also a more efficient use of activated sludge in water treatment plants. The most noticeable effect would be the support to the development of rules for the assessment and management of hazards (already regulated by Directive 2012/18/EU) to avoid the negative impact of the animal hide/skin processing on the environment and people's health.
Water directive are involved both in the reduction of wastewater load and the reduction of water use; furthermore, the increase in biodegrability (BOD/COD) for fat-liquoring-defattening-dyeing residual baths at laboratory level, affording better efficacy in wastewater treatment and there is an increase of biodegradability of new fatliquoring molecules. This is also a direct response to bioaccumulation, since bioaccumulation is by definition connected with non-biodegradability. The increase in biodegradation is a direct response to the problem caused by chloro-paraffins, which have the problems of bioaccumulation, particularly for the chain length up to 13, as evidenced by REACH prescriptions.
LIFETAN strategy also addresses the indications set in the recent Communication "Towards a circular economy: A zero waste programme for Europe" (COM(2014) 398 final). Technologies are applied for waste reduction, recycling and recovery of secondary raw materials and creating examples of Circular Economy practice.
The development of new naturalized materials, substituting the use of fossil-based ones, contributes to the objective of the resource efficient flagship initiative (COM 2011 (21)). In particular, within the flagship initiative, the Roadmap to a Resource Efficient Europe (COM(2011) 571) outlines how we can transform Europe's economy into a sustainable one by 2050, proposing ways to increase resource productivity and decouple economic growth from resource use and its environmental impact.
Final products were impacted with the European Eco-label for footwear (Decision 2009/563/UE); but also naturalized products could be involved in European Eco-label.
During the project implementation, in order to diffuse the TAN project results and protocols, the partners kept in close contact with different institutions who deal with leather and related sectors at as much an intercommunity as a global level, such as industrial federations, business associations, and in particular UNIC (partners are involved in Unic) and COTANCE (the representative body of the European leather industry), etc. Also, these contacts were used to promote the project dissemination at a European level, because these organisations have numerous members from the leather sectors.
The European Commission, with the Recommendation of 9 April 2013 on the use of common methods to measure and communicate the life cycle environmental performance of products and organisations, establishes a common methodological approach to enable Member States

and the private sector to assess, display and benchmark the environmental performance of products, services and companies based on a comprehensive assessment of environmental impacts over the life-cycle. In this framework, a pilot test devoted to “leather” is in progress, guided by COTANCE. The LIFETAN project can represent an important contribution to this initiative and other environmental indicators were calculated according to the PCR for Finished Bovine Leather (Project specific indicators).
Directive 96/64/EC regarding Integrated Pollution Prevention Control promotes the adoption of measures allowing the reduction in origin of pollution and the use of Best Available Techniques (BAT), as is the natural products fatting technique. Already PODEBA results have been proposed as ET (natural bating agent); also LIFETAN results were collected in order to compile another ET proposal.

7. Key Project-level Indicators

This chapter will list all the KPIs selected and estimated at the beginning of the project. Detailed description is given in Del. E2 "Report On Progress On Performance Indicators"; this deliverable reports the final values obtained from Water Analysis, Life Cycle Assessment and Project Data concerning products substitution.

Indicators selection derive by different needs: Project Specific Indicators, chosen in a list defined by the LIFE programme, with the aim of evaluating the improvement due to the introduction of the new products in the production system; LCA indicators, that will give the opportunity to compare standard and new technologies from an environmental point of view; water analysis, chosen to propose LIFETAN as an emerging technique in the Best Available Technique system.
Here below are listed the Project indicators selected for the LIFETAN project. The list has been validated and represents a representative number of specific context indicators that allow having a clear vision of the effects of the project on different sectors.
Numbers reported refer to the one defined in the Project Indicator website, the validated table can be consulted in Del. E2.

Project indicators data sources
- Direct measure for wastewater characterization,
- LCA to evaluate the effect of LIFETAN cycles on the main LCA indicators,
- Activities carried out during the project development.

Project Indicators Measuring Units
The values express the state of play as regards the relevant descriptor in or as standard text or symbols and directly corresponds to the relevant measuring unit.
The values are measured and/or estimated:

- at the beginning of the project;
- at the end of the project;
- 3 years after the end of the project period in the measuring unit, they are raw data values and not percentages.

The measuring units indicate how the descriptor is measured. It could be a single unit like length, weight or time or combinations of these like tonnes for year.
For the specific case analysed in this project, measuring units have been calculated as follows starting form results of previous projects.
Starting from the total quantity of leather tanned in a year (2012), an estimated quantity of leather treated with the LIFETAN techniques (**2.7 t/y of fresh salted raw hides/skins**) have been calculated and knowing the quantity of specific products for the tanning process, the quantity of each product have been calculated. Actually, during the project a processing of **3.4 t/y** has been achieved.
At the same time, expected results for 3 years after the end of the projects have been estimated (application to **5000 t/y of fresh salted raw hides/skins**).

LIFETAN Project Indicators for water consume, point source pollution, Waste management and Chemical released and substitution are in table 7.1.

PARAMETERS	At the beginning	At the end	3 Years beyond	Units	Comments
Water consumption for production	50	50	50	m3/unit produced	NO CHANGES
Point source pollution					
EEA_3133-03-7 - CODCr	168000	168000	167700	tonnes/year	
EEA_31615-01-7 - Total nitrogen	10500	10500	10475	tonnes/year	
EEA_33-08-9 - Chromium 3+	4800	4800	4760	tonnes/year	
Waste Management					
04 02 19* sludges from on-site effluent treatment containing hazardous substances	120000	120000	119000	tn/year	200 kg/tonn raw hides avoided . PREVENTION
04 01 08 waste tanned leather (blue sheetings, shavings, cuttings, buffing dust) containing chromium	156000	156000	154700	tn/year	260 kg/tonn raw hides avoided . PREVENTION
02 01 06 animal faeces, urine and manure (including spoiled straw), effluent, collected separately and treated off-site	500000	500000	499850	tn/year	30kg/tonn raw hides avoided RECYCLING
Chemicals released					
Nonylphenol, ethoxylated IUPAC name: Alkylphenol Ethoxylate 500-024-6	1	0	0	kg/year released	
Chemicals substitution					
Alkylphenol Ethoxylate 500-024-6 - Other chemical 11 kg per ton of raw hides	0	29.7	110550	kg/year substituted	
Poultry manure - Ammonium sulphate 231-984-1	0	16.2	60300	kg/year substituted	
Chlorinated Palm Oil - Alkanes, C14-17, chloro - Process related name: chlorinated paraffins, C14-17 287-477-0 - Partial chemical substitution	0	216	804000	kg/year substituted	
Chromium hydroxide sulphate 914-129-3 - Oxazolidine (Oxatan) 80 kg/t raw hides	0	135	502000	kg/year substituted	

Table 7.1. LIFETAN Project Indicators for water consume, point source pollution, Waste management and Chemical released and substitution

Resource efficiency - circular economy

- *02 01 06 animal faeces, urine and manure (including spoiled straw), effluent, collected separately and treated off-site*
  0.015 kg/kg raw hide, equivalent to 0.081 kg/m^2 finished leather,
  With a number of entities (tannery involved) of 1 at the beginning of the project, 2 at the end of the project and 5 after 3 years.

- *02 02 99 wastes from the preparation and processing of meat, fish and other foods of animal origin - wastes not otherwise specified*
  0.0004 kg/kg raw hide, equivalent to 0.002 kg/m^2 finished leather.

Air - emissions

- *PM 2.5*
- *CO*
- *NH3*
- *Other (Odour)*
- *SO2/SOx*

To calculate the expected pollutant reduction, results from previous project have been extrapolated and adapted considering the share of leather quantity estimated to be tanned with LIFETAN products.
As it was not possible forecast the combined effects of the LIFETAN products, for some indicators the improvement obtained by one of the LIFETAN product have been used. Final results may differ from what forecasted.
In 2 are reported the results obtained in Podeba Project starting from the emissions "at the beginning" to the reduction obtained "at the end", values 3 year beyond are the same because is not expected an improving of the product used.

	at the beginning	at the end	3 years beyond
PM 2,5 (kg)	0,0000104	0,0000098	0,0000098
CO (kg)	0,000097	0,000067	0,000067
NH3 (kg)	0,0000057	0,0000035	0,0000035
SO2/SOx (kg)	0,00032	0,00053	0,00053

Table 7.2 - Expected pollutants reduction per kg of product (Podeba project)

In Table 7.3 are reported results considering the use of Podeba Projects product applied in the EU leather context considering an increase in the share of leather treated. Results are not so evident because the share of leather treated is even after 3 years less than 1% of the total production (0,7 %).

	at the beginning	at the end	3 years beyond
PM 2,5 (kg/day)	0,3191	0,3191	0,3190
CO (kg/day)	2,9764	2,9764	2,9699
NH3 (kg/day)	0,1749	0,1749	0,1744
SO2/SOx (kg/day)	9,8192	9,8192	9,8652

Table 7.3- Expected pollutants reduction per total leather production

These data are compared with LCA analysis in LIFETAN project, for the 4 cycles foreseen in LIFETAN, data deriving from the inventory phase of the LCA model have been used to evaluate emissions to air of some major pollutants. Some extra results have been collected to answer to the Project Specific Indicators of the Life programme. In particular, Carbon

Dioxide, Methane, Sulphur hexafluoride, Fine Particulate Matter ($PM_{2.5}$), Ammonia and Sulphur Oxides have been collected and reported in 7.4. The case of LIFETAN tanning cycle 4 is reported in the following.

	Commercial	LIFETAN	LIFETAN (no Bionad)	LIFETAN (EDF20+Podeba)
CO_2	6,10E+04	6,45E+04	5,35E+04	6,10E+04
CH_4	2,45E+02	2,54E+02	2,09E+02	2,44E+02
SF_6	8,05E-03	8,10E-03	7,10E-03	8,05E-03
$PM_{2.5}$	7,80E+01	8,15E+01	7,50E+01	7,75E+01
NH3	1,77E+01	4,12E+01	1,77E+01	1,77E+01
SO_2/SO_X	5,75E-04	6,05E-04	3,86E-04	5,70E-04
CO	1,56E-01	1,78E-01	1,61E-01	1,56E-01

Table 7.4 - Emission on air of some selected gasses for Tradelda finished leather (Ltc 4) per 1000 kg of raw hides

Results reported refer to a ton of raw hides and show how Commercial and LIFETAN products have a comparable emissions profile; the emissions are lower in the case of LIFETAN without Bionad. It is important to remark that some products, in particular Bionad colours, are not yet produced at an industrial scale.
The 4 different recipes have different figures for gas emissions, but of the same order (C.5 Annex I).

Jobs

- *No. of full-time equivalent*

- 0.7 during the project (Additional for ENEA for 8 month),
- 60 person after 3 years of the end of the project for the production of new natural products. For example, the production of 4800 t/y of natural bating agent will create 6 new full-time equivalent jobs.

Cost reduction expected in case of continuation/ replication/transfer after the project end
125000 after 3 years - expected cost reduction in tannery (5 Euros/ton raw hides connected to bating phase (PODEBA results), saving in sludge and waste disposal) and expected saving costs in the different chains (i.e less costs for poultry farmer for collocation of manure, saving for serum disposal - lactose production) for a total of 25 euro/ton raw hides

Entry into new geographic areas-
Italy (Tuscan and Veneto district) and Spain
There was a change in strategy, targeting towards made in Italy, quality and possible high quality and high fashion. The choice of niche market to introduce the new products. Later diffusion in the world.
The details of LIFETAN Performance Indicators, calculated on the basis of project findings are contained in ANNEX 1 - FINAL REPORT "LIFETAN Performance Indicators".