



INSTITUTO CENTRAL DE GESTIÓN DE LA INVESTIGACIÓN

“Año del Bicentenario, de la consolidación de nuestra Independencia,  
y de la conmemoración de las heroicas batallas de Junín y Ayacucho”

Lima, 26 de marzo del 2024

Oficio N° 094-2024-OPI-ICGINV-VRIN-UNFV.

Econ.

**JOSÉ CONDORI QUÍSPE**

Jefe de la Dirección General de Administración

Presente. –

Asunto: SERVICIO DE PUBLICACIÓN EN REVISTA INDIZADA  
Docente: Doris Esenarro Vargas

Referencia: OFICIO N° 1064-2024-UCSB-OASG-UNFV  
PROVEIDO N° 3328-2024-DIGA-UNFV

Tenemos a bien dirigirnos a usted con la finalidad de saludarlo cordialmente, asimismo en base a los documentos de la referencia, se devuelve el presente expediente con el formato SIGA, con la finalidad que se sirva autorizar y continuar el trámite de pago en revista indizada, para la publicación del artículo “Use of Digital Tools (Wikihouse System) in Multi-Local Social Housing”.

Sin otro particular, aprovecho la ocasión para expresarle las muestras de mi consideración.

Atentamente.



Firmado digitalmente por:  
MONROY CORREA GRACIELA MARTINA  
FIR 09715476 hard  
Motivo: Soy el autor del documento  
Fecha: 26/03/2024 15:25:01-0500

**Dra. Graciela Martina Monroy Correa**  
Jefa de Oficina de Proyectos de Investigación

**Dr. José Héctor Livia Segovia**

Director del Instituto Central  
de Gestión de la Investigación

Firmado digitalmente por:  
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NT: 013014- 2024



PEDIDO DE SERVICIO N°

000226

UNIDAD EJECUTORA : 001 UNIVERSIDAD NACIONAL FEDERICO VILLARREAL  
NRO. IDENTIFICACIÓN : 000102

Tipo Uso : Consumo

Dirección Solicitante : INSTITUTO CENTRAL DE GESTIÓN DE LA INVESTIGACION- VRIN  
Entregar a Sr(a) : LIVIA SEGOVIA JOSE HECTOR  
Fecha : 26/03/2024  
Actividad Operativa : C0523 SUBVENCIÓN DE PAGO POR CARGO DE PROCESAMIENTO DE ARTÍCULOS EN REVISTAS DE  
Motivo : PUBLICACIONES DE ARTÍCULOS CIENTÍFICOS EN REVISTA INTERNACIONAL, DOCENTE DORIS ESENNARRO VARGAS

FF/Rb	META / MNEMONICO	Función	División Func.	Grupo Func.	Programa	Prod/Pry	Act/Ai/Obr
1-00	0024	22	048	0015	9002	3999999	5001792

Código	Descripción / Términos de Referencia	Clasificador	Valor S/.	Unidad Medida
150100020007	PUBLICACIONES DE ARTÍCULOS CIENTÍFICOS EN REVISTA INTERNACIONAL	2.3. 2 2. 4 1	15,200.00	SERVICIO



Firma del Solicitante



Firma Autorizada



## ANEXO 1

### SOLICITUD DE FINANCIAMIENTO PARA PUBLICACIÓN (DOCENTES)

Lima de 17 Febrero del 202

Señor Vicerrector (a) de la Universidad Nacional Federico Villarreal  
Pedro Amaya Pingo

Yo, DORIS ESENARRO VARGAS, docente adscrito a la Facultad de Ingeniería Geográfica, Ambiental y Ecoturismo. Ordinario, en la Categoría: Auxiliar a TC.  
Con domicilio en Av. Juan Pezet 1505 Dpto. 702, distrito de San Isidro,  
Identificado con código N° 205038, DNI N°09471808, e-mail [desenarro@unfv.edu.pe](mailto:desenarro@unfv.edu.pe), en calidad de coautor del artículo **“USE OF DIGITAL TOOLS (WIKIHOUSE SYSTEM) IN MULTI-LOCAL SOCIAL HOUSING”**

Solicito financiamiento para su publicación en la revista Sustainability,  
Teniendo como coautores:

Emerson Porras (Coautor)  
Hardy Ventura (coautor)  
Julio Figueroa (coautor)  
Vanessa Raymundo (coautor)  
Lorena Castañeda (coautor)

Para lo cual se adjunta:

- Artículo en PDF
- Certificado de aceptación de publicación
- Factura de costo de publicación de la revista.

Atentamente,

Doris Esenarro Vargas  
Docente responsable



## **FORMATO N° 01**

### **TÉRMINOS DE REFERENCIA PARA SERVICIOS**

#### **1. ÁREA USUARIA**

Instituto Central de Gestión de la Investigación

#### **2. DENOMINACIÓN DE LA CONTRATACIÓN**

Servicio de publicación de artículo científico en revista indizada internacional

#### **3. FINALIDAD PÚBLICA**

El Instituto Central de Gestión de la Investigación tiene como parte de sus funciones, promover la investigación, producción científica, innovación y emprendimiento de los docentes y estudiantes de la Universidad Nacional Federico Villarreal, estableciendo estrategias que coadyuven a cumplir con las metas propuestas.

Debiendo contar para ello con la evidencia necesaria de las múltiples investigaciones que realizan los docentes y estudiantes de la comunidad villarrealina, a través de la publicación de los artículos en revistas indexadas de alto impacto a nivel internacional.

#### **4. ANTECEDENTES**

En el marco de las estrategias establecidas nuestra casa de estudios ha a través de sus recursos directamente recaudados otorgara financiamiento por servicio de publicación de artículos científicos en revistas especializadas e indexadas a nivel internacional. R. N° 236-2022-UNFV San Miguel, 28 abril de 2022. Directiva LINEAMIENTOS Y PROCEDIMIENTOS PARA EL ACCESO AL FINANCIAMIENTO DEL SERVICIO DE LAS PUBLICACIONES EN REVISTAS INDIZADAS, (web of science, scopus, scielo).

#### **5. OBJETIVO DE LA CONTRATACIÓN**

Financiar el servicio de publicación de artículos científicos en una revista indexada a nivel Internacional.

#### **6. REQUERIMIENTO, CARACTERÍSTICAS Y CONDICIONES**

##### **6.1. REQUERIMIENTO**

<b>N° Ítem</b>	<b>Código Siga</b>	<b>Descripción del servicio</b>	<b>Unidad de Medida</b>	<b>Cantidad</b>
01	000226	Publicación de Artículo en Revista Científica	Servicio	01

##### **6.2. CARACTERÍSTICAS DE LA REVISTA**

Deberá ser una revista científica de investigación a nivel internacional.

Deberá tener publicaciones semi-mensual y acceso libre e inmediato a su contenido a través de las páginas web.

La revista deberá figurar en las bases de datos especializadas en revistas científicas indexadas, como: scopus, web of science, scielo.

##### **6.3. RESPONSABILIDAD DEL CONTRATISTA**

###### **6.3.1. Plazo de reposición**

En caso de detectarse errores ortográficos y/o gramaticales, luego de la publicación del artículo en la revista indizada, el área usuaria dentro de los dos (02) días hábiles siguientes de realizada la publicación, solicitará a través de la Oficina de Abastecimiento y Servicios Generales, se notifique al proveedor el sentido de las observaciones y el plazo para su reposición (nueva publicación).

### 6.3.2. Garantía comercial

El proveedor otorgará una garantía comercial para avalar que el servicio prestado cumple con todas las características y condiciones establecidas en los términos de referencia, el cual no podrá ser menor a un (01) año, computados a partir de la entrega de la Constancia del artículo publicado.

Para lo cual una vez identificado el servicio que presenta defectos, se notificará al proveedor para su reposición inmediata en un plazo máximo de tres (03) días calendario computados luego de la notificación de la carta por parte de la Oficina de Abastecimiento.

### 6.3.3. Responsabilidad por vicios ocultos

El plazo máximo de responsabilidad del contratista es de un (01) año, contado a partir de la conformidad otorgada por la Entidad.

## 6.4. LUGAR DONDE SE EJECUTARÁ LA PRESTACIÓN

No aplica

## 6.5. CONDICIONES DE LA PRESTACIÓN

La publicación se realizará a través de una plataforma especializada de forma virtual, de acuerdo a las condiciones establecidas por el proveedor.

## 6.6. PLAZO DE EJECUCIÓN DE LA PRESTACIÓN

Entregable	Plazo
Constancia del artículo publicado	Hasta cien (100) días calendario siguientes, computados a partir del día siguiente de recibido el pago correspondiente.

## 6.7. FORMA DE PAGO

La Entidad debe pagar las contraprestaciones pactadas a favor del contratista de forma previa en pago único, a la publicación de artículo por derecho a la revista indexada, siempre que se verifiquen las condiciones establecidas en los términos de referencia y previa presentación del Formato N° 04 - Autorización para realizar el pago previo a la publicación por derecho a la revista indexada, por parte del área usuaria

## 6.8. CONFORMIDAD

La conformidad de la prestación será dada expresamente por el Director del Instituto Central de Gestión de la Investigación - ICGI de la UNFV, dentro de los dos (02) días hábiles siguientes de la verificación y cumplimiento de la prestación de acuerdo al requerimiento y la orden de servicio.

## 6.9. PENALIDADES

No aplica.

## 6.10. CONFIDENCIALIDAD

El proveedor deberá guardar absoluta confidencialidad en el manejo de la información y documentación a la que tenga acceso durante la prestación del servicio, no podrá revelar detalles sobre el alcance del servicio a terceros, excepto cuando resulte estrictamente necesario para el cumplimiento de la prestación. En ambos casos el proveedor deberá dar cumplimiento y será responsable de la aplicación a todas las políticas definidas por UNFV en materia de seguridad de la información.

## 6.11. VICIOS OCULTOS

El plazo máximo de responsabilidad del contratista es de un (01) año, contado a partir de la conformidad otorgada por la Entidad.

## 6.12. NORMATIVA ESPECÍFICA



No aplica

## 6.13. ANEXOS U OTROS DOCUMENTOS EN RELACIÓN CON LA CONTRATACIÓN.





- Carta de aceptación remitida por el proveedor.
- invoice remitida por el proveedor.
- Formato de Validación de los Términos de Referencia.
- Formato de Conversión de moneda y Cálculo de obligaciones tributarias.
- Formato de Autorización para realizar el pago previo a la publicación porderecho a la revista indexada, de ser caso.
- Ficha técnica de la revista.  
El articulo a publicar en formato digital.



FORMATO Nº 2					
VALIDACIÓN DE LOS TÉRMINOS DE REFERENCIA					
Revisión y/o verificación del cumplimiento de los Términos de Referencia					
1	DENOMINACIÓN DE LA CONTRATACIÓN			"Publicación de artículo en revista científica"	
2	DEPENDENCIA USUARIA			INSTITUTO CENTRAL DE GESTION DE LA INVESTIGACION	
ÍTEM Nº	DESCRIPCIÓN DEL ÍTEM			PROVEEDOR	
	Descripción clara y precisa del objeto de la contratación	Cantidad	Cumple	Razón Social	MDPI
	Pertenecer a una sociedad internacional con reconocida trayectoria en niveles K-12.A12	1	SI	RUC	PROVEEDOR DEL EXTRANJERO
	La editorial dueña de la revista debe tener varias publicaciones especializadas en enseñanza multicultural.	1	SI	Número de Cotización / Invoice / Factura / Orden	2754136
	La revista debe figurar en las bases de datos especializadas en revistas científicas indexadas como: Scopus.		SI / NO	Fecha del documento remitido	27/01/2024
				Otros (pais proveedor)	SUIZA
3	NOTAS / OBSERVACIONES		SE REQUIERE EL PAGO PREVIO		
4	FECHA DE ELABORACIÓN DEL DOCUMENTO:		14/03/2024		
5	EMITIDO Y APROBADO POR:				
	Dr. Jose Hector Livia Segon Director del Instituto Central de Gestion de Investigacion		Dra. Graciela Monroy Correa Jefa de la Oficina de Investigacion de Proyectos		

FORMATO Nº 3					
CONVERSIÓN DE MONEDA Y CÁLCULO DE OBLIGACIONES TRIBUTARIAS					
1	DENOMINACIÓN DE LA CONTRATACIÓN	"Publicación de artículo en revista científica"			
2	DEPENDENCIA USUARIA	INSTITUTO CENTRAL DE GESTION DE LA INVESTIGACION			
3	DATOS DEL PROVEEDOR				
	Razón Social	MDPI			
	RUC	PROVEEDOR DEL EXTRANJERO			
	Número de Cotización / Invoice / Factura / Orden	2754136			
	Fecha del documento remitido	27/01/2024			
	Moneda y monto del importe	Moneda del importe:	USD	Monto del importe:	2,776.62
3	CALCULO DE PAGO				
	Moneda y monto del importe	USD 2,776.62			
	Tipo de cambio SBS al día 13/03/2024	S/ 3.671			
	Moneda y monto del importe según conversión	S/ 10,193.00			
	Calculo de pago IGV no domiciliado (18%)	S/ 1,834.74			
	Periodo en que se realiza el calculo de pago IGV no domiciliado	Mar-24			
	Retenciones (30%) según sea el caso	S/ 3,057.90			
	Gastos operativos / Comisiones	S/ 114.36			
	IMPORTE TOTAL PARA CERTIFICAR	S/ 15,200.00			
3	NOTA:	Para la contratación de servicios con proveedores no domiciliados en el país, se aplicarán las normas tributarias y tratados internacionales correspondientes y vigentes a la fecha de elaboración de presente documento.			
4	FECHA DE ELABORACIÓN DEL DOCUMENTO:	14/03/2024			
5	 Dr. Jose Hector Livia Segovia Director del Instituto Central de Gestion de Investigacion		 Dra. Graciela Monroy Correa Jefa de la Oficina de Investigacion de Proyectos		



FORMATO Nº 4			
AUTORIZACIÓN PARA REALIZAR EL PAGO PREVIO A LA PUBLICACIÓN POR DERECHO A LA REVISTA INDEXADA			
1	FECHA DE EMISIÓN DEL DOCUMENTO	14/03/2024	
2	DEPENDENCIA USUARIA	INSTITUTO CENTRAL DE GESTION DE LA INVESTIGACION	
3	DATOS DEL PROVEEDOR	Razón Social	MDPI
		RUC / Código	PROVEEDOR DEL EXTRANJERO
		Dirección	SUIZA
		Nombre de contacto	Prof. Dr. Marc A. Rosen
		Número telefónico	+41616837734
		E-mail	<a href="https://www.mdpi.com/journal/sustainability">https://www.mdpi.com/journal/sustainability</a>
4	DATOS DE LA CONTRATACIÓN	Ítem	1
		Descripción del objeto de la contratación	"SERVICIO DE PUBLICACIÓN DE ARTÍCULO EN REVISTA INDIZADA INTERNACIONAL"
		Monto de la contratación	S/.15,200.00
		Forma de pago	PAGO PREVIO
		Plazo de la prestación	HASTA CIEN DIAS CALENDARIOS SIGUIENTES CONTADOS A PARTIR DEL DIA SIGUIENTE DE RECIBIDO EL PAGO CORRESPONDIENTE
		Validación de TdR	SEGÚN FORMATO ADJUNTO
6	OBSERVACIONES		
	PROVEEDOR CON SEDE EN SUIZA		
7	AUTORIZACIÓN EN CASO DE REALIZAR EL PAGO PREVIO A LA PUBLICACIÓN		
	El funcionario que suscribe el presente documento, dada la naturaleza de la contratación autoriza la realización del pago previo a la publicación, a fin de alcanzar la finalidad de la contratación.		
	CONDICIONES PARA EL PAGO PREVIO	Monto a pagar	S/.15,200.00
		Plazo para realizar el pago	30 DIAS CALENDARIOS
		Nombre y dirección del banco destino	UBS SWITZERLAND AG, Bahnhofstrasse 45, 8001 Zurich Switzerland
		Nombre de cuenta	MDPI AG
		Número de cuenta	023300222721.62C
		CCI / Código Swift	UBSWCHZH80A
		Código ABA / IBAN	CH92 0023 3233 2227 2162C
		Otras consideraciones	-----
8	<div><div></div><div></div></div> <div><div>Dr. Jose Hector Livia Segovia Director del Instituto Central de Gestion de Investigacion</div><div>Dra. Graciela Monroy Correa Jefa de la Oficina de Investigacion de Proyectos</div></div>		
	NOMBRE, FIRMA Y SELLO DEL FUNCIONARIO RESPONSABLE DEL ÁREA USUARIA		



## Formato 12

### FICHA TECNICA DE LA REVISTA

<b>Nombre</b>	SUSTAINABILITY - MDPI
<b>URL</b>	<a href="https://www.mdpi.com/journal/sustainability">https://www.mdpi.com/journal/sustainability</a>
<b>ISSN</b>	2071-1050
<b>Indexaciones</b>	Scopus, SCIE y SSCI (Web of Science), GEOBASE, GeoRef, Inspec, AGRIS, RePEc, CAPlus/SciFinder y otras bases de datos.
<b>Año de publicación</b>	2009
<b>Periodicidad</b>	SEMI MENSUAL
<b>Editor</b>	Prof. Dr. Marc A. Rosen
<b>Factor de impacto</b>	3,9 (2022)
<b>Cuartil de la revista</b>	JCR - Q2 (Estudios ambientales ) / CiteScore - Q1 (Geografía, planificación y desarrollo )
<b>Entidad patrocinadora</b>	MDPI
<b>País</b>	Suiza



ANEXO N° 06: APROBACIÓN DE MODIFICACIONES AL CUADRO MULTIANUAL DE NECESIDADES N° 00000205

UNIDAD EJECUTORA : 001 UNIVERSIDAD NACIONAL FEDERICO VILLARREAL  
NRO. IDENTIFICACIÓN : 000102

Fecha de Solicitud	N° de Solicitud de Modificación	Código Ítem N.-	Descripción del Ítem	Unidad de Medida	CANTIDAD Y/O VALORES			
					EXCLUSIÓN		INCLUSIÓN	
					Cantidad Total	Valor Total S/	Cantidad Total	Valor Total S/
102.04.03.1 - Instituto Central De Gestión De La Investigacion- Vrin								
14/03/2024	0000000301	150100020007	PUBLICACIONES DE ARTÍCULOS CIENTÍFICOS EN REVISTA INTERNACIONAL	Servicio	0.00	0.00	0.00	15,200.00

- 1/ La información registrada en el presente Anexo corresponde a campos mínimos y obligatorios que pueden ser ampliados por la Entidad del Sector Público u organización de la entidad.
- 2/ La información registrada en los campos de "exclusión" e "inclusión" considera la cantidad y/o valor acumulado de todos los años de la programación.
- 3/ El campo de "cantidad total" se completa solo en el caso de bienes.
- 4/ La presente información tiene carácter de Declaración Jurada; por lo que, en señal de conformidad y en representación de la Entidad del Sector Público u organización de la entidad, se suscribe:



Firma 1: Responsable del Área involucrada en la gestión de la CAP



Firma 2: Titular de la Entidad u Organización de la entidad, o a quien se hubiera delegado dicha facultad

ANEXO N° 05: SOLICITUD DE MODIFICACIÓN DEL CUADRO MULTIANUAL DE NECESIDADES N° 0000000301

UNIDAD EJECUTORA : 001 UNIVERSIDAD NACIONAL FEDERICO VILLARREAL  
NRO. IDENTIFICACIÓN : 000102

Centro de Costo: 102.04.03.1 INSTITUTO CENTRAL DE GESTIÓN DE LA INVESTIGACION- VRIN  
Fecha de Solicitud: 14/03/2024

ÍTEM			CANTIDAD Y/O VALORES			
Código Ítem N.-	Descripción del Ítem	Unidad de Medida	EXCLUSIÓN		INCLUSIÓN	
			Cantidad Total	Valor Total S/	Cantidad Total	Valor
150100020007	PUBLICACIONES DE ARTÍCULOS CIENTÍFICOS EN REVISTA INTERNACIONAL	Servicio	0.00	0.00	0.00	

Sustento para la aprobación de modificaciones del CMN, al día hábil siguiente de su presentación (numeral 27.4 del artículo 27):  
De ser el caso, indicar el/los año(s) que corresponda(n) realizar la inclusión o exclusión de la programación:

- 1/ La información registrada en el presente Anexo corresponde a campos mínimos y obligatorios que pueden ser ampliados por la Entidad del Sector Público u organización de la entidad.
- 2/ La información registrada en los campos de "exclusión" e "inclusión" considera la cantidad y/o valor acumulado de todos los años de la programación.
- 3/ El campo de "cantidad total" se completa solo en el caso de bienes.
- 4/ La presente información tiene carácter de Declaración Jurada; por lo que, en señal de conformidad y en representación del Área usuaria, se suscribe:



Firma: Responsable del Área Usuaría



V°B° Dr. Jose H. Liia Segovia

Carta de aceptación remitida por el proveedor:





**Doris Esenarro**  
FACULTAD DE INGENIERIA EN ECOTURISMO -  
UNFV  
UNIVERSIDAD NACIONAL FEDERICO  
VILLARREAL UNFV  
C. Carlos Gonzales Candamo 295, San Miguel  
15088-Lima Peru  
LIMA 01  
Peru

## INVOICE

MDPI  
St. Alban-Anlage 66  
4052 Basel  
Switzerland  
Tel.: +41 61 683 77 34  
E-Mail: [billing@mdpi.com](mailto:billing@mdpi.com)  
Website: [www.mdpi.com](http://www.mdpi.com)  
VAT nr. CHE-115.694.943

Date of Invoice: 27 January 2024  
Manuscript ID: sustainability-2754136  
Invoice Number: 2754136  
Your Order: by e-mail ([desenarro@unfv.edu.pe](mailto:desenarro@unfv.edu.pe)) on 19 November 2023  
Article Title: "Use of digital tools (wikihouse system) in multi-local social housing"  
Name of co-authors: Doris Esenarro, Emerson Porras, Hardy Ventura, Julio Figueroa, Vanessa Raymundo and Loren a Castañeda  
[Additional Author Information](#)  
Terms of payment: 5 days  
Due Date: 1 February 2024  
License: CC BY

Description	Currency	Amount
Article Processing Charges	USD	2 776.62
Subtotal without VAT	USD	2 776.62
VAT (0%)	USD	0.00
<b>Total with VAT</b>	<b>USD</b>	<b>2 776.62</b>

### Accepted Payment Methods

#### 1. Online Payment by Credit Card in US Dollars (USD)

Please visit <https://payment.mdpi.com/2690260> to pay by credit card. We accept payments in US Dollars (USD) made through VISA, MasterCard, Maestro, American Express, Diners Club and Discover.

#### 2. Paypal in US Dollars (USD)

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#### 3. Wire Transfer in US Dollars (USD)

Important: **Please provide the Manuscript ID (sustainability-2754136) when transferring the payment**

Payment in USD must be made by wire transfer to the MDPI bank account. Banks fees must be paid by the customer for both payer and payee so that MDPI can receive the full invoiced amount.

IBAN: CH92 0023 3233 2227 2162 C  
SWIFT Code / BIC (Wire Transfer Address): UBSWCHZH80A  
Beneficiary's Name: MDPI AG  
Beneficiary's Address: St. Alban-Anlage 66, 4052 Basel, Switzerland  
Bank Account Number (USD, US Dollars Account for MDPI): 0233 00222721.62C  
Bank Name: UBS Switzerland AG  
Bank Address:

UBS Switzerland AG  
Bahnhofstrasse 45  
8001 Zürich  
Switzerland

For detailed payment instruction, or for more alternative payment methods, visit the website at: <https://www.mdpi.com/about/payment>.

Invoiced Amount in CHF: 2 400.00

Exchange rate applied to this invoice 29 January 2024: 0.86436 USD/CHF



Universidad Nacional  
**Federico Villarreal**

## INSTITUTO CENTRAL DE GESTIÓN DE LA INVESTIGACIÓN

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PROVEIDO N° 226-2024-ICGI-VRIN-UNFV

RECURRENTE: Bach. MANUEL ORTIZ CHAVEZ  
Jefe Unidad Contrataciones y Servicios Básicos

ASUNTO: REMITO EXPEDIENTE CON APROBACIÓN DE ANEXO 06  
PARA EL SERVICIO DE PUBLICACIÓN DE USE OF DIGITAL  
TOOLS (WIKIHOUSE SYSTEM) IN MULTI-LOCAL SOCIAL  
HOUSING.

REFERENCIA: OFICIO N° 1064-2024-UCSB-OASG-UNFV

NT: 13014-2024

FECHA : Lima, 26 de marzo del 2024

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PASE A : **Dra. Graciela M. Monroy Correa**  
Jefa de la Oficina de Proyectos de investigación.

PARA : Su atención y fines correspondiente.

  
**Dr. JOSÉ H. LIVIA SEGOVIA**  
Director

Instituto Central de Gestión de la Investigación

Cc. **CARLOS DOMINGUEZ**  
Adj.: 052 folios



**UNIDAD DE CONTRATACIONES Y SERVICIOS BASICOS**

*"Año del Bicentenario, de la consolidación de nuestra Independencia, y de la conmemoración de las Heroicas Batallas de Junín y Ayacucho"*

Pueblo Libre, 25 de marzo de 2024

**OFICIO N° 1064-2024-UCSB-OASG-UNFV**

**Dr. JOSE HECTOR LIVIA SEGOVIA**

Director del Instituto Central de Gestión de la Investigación

Presente. –

**Asunto:** REMITO EXPEDIENTE CON APROBACIÓN DE ANEXO 06  
PARA EL SERVICIO DE PUBLICACIÓN DE USE OF DIGITAL  
TOOLS (WIKIHOUSE SYSTEM) IN MULTI-LOCAL SOCIAL  
HOUSING

**Referencia:** PROVEIDO N° 3328-2024-DIGA-UNFV

Es grato dirigirme a usted para saludarle cordialmente y, en atención al documento de la referencia poner de conocimiento que la Dirección General de Administración procedió con la aprobación del anexo 06 para el SERVICIO DE PUBLICACIÓN DE USE OF DIGITAL TOOLS (WIKIHOUSE SYSTEM) IN MULTI-LOCAL SOCIAL HOUSING.

Aprovecho la ocasión para renovarle las muestras de mi especial consideración y estima personal.

Atentamente,



V°B°

**LIC. JULIO GREGORIO TALLA RAMOS**

Jefe

Oficina de Abastecimiento y Servicios Generales



**Bach. MANUEL JESUS ORTIZ CHÁVEZ**

Jefe

Unidad de Contrataciones y Servicios Básicos

MOCH/nbch  
NT: 13014-2024



""

**PROVEIDO N° 3328-2024-DIGA-UNFV**

**RECURRENTE** LIC. JULIO GREGORIO TALLA RAMOS  
OFICINA DE ABASTECIMIENTO Y SERVICIOS GENERALES - OASG  
OFICIO N° 1026-2024-UCSB-OASG-UNFV

**NT** 013014 - 2024

**ASUNTO** SOLICITUD DE APROBACION DE ANEXO 06

**FECHA** 22 DE MARZO DEL 2024

**DESTINATARIO** LIC. JULIO GREGORIO TALLA RAMOS  
OFICINA DE ABASTECIMIENTO Y SERVICIOS GENERALES - OASG

**PARA** SE REMITE ANEXO N° 06: APROBACIÓN DE MODIFICACIONES AL CUADRO  
MULTIANUAL DE NECESIDADES N° 00000205, APROBADO EN EL SIGA, A FIN  
QUE, SE SIRVA INFORMAR AL AREA USUARIA DE ACUERDO A LOS  
LINEAMIENTOS ESTABLECIDOS Y NORMATIVA VIGENTE.

ATENTAMENTE,



**ECON. JOSÉ GUALBERTO CONDORI QUÍSPE**  
JEFE

JGCQ / rdly

**FOLIOS:** 01



**UNIDAD DE CONTRATACIONES Y SERVICIOS BASICOS**

*"Año del Bicentenario, de la consolidación de nuestra Independencia, y de la conmemoración de las heroicas batallas de Junín y Ayacucho"*

Pueblo Libre, 20 de marzo del 2024

**OFICIO N° 1026-2024-UCSB-OASG-UNFV**

Señor Economista.

**JOSE GUALBERTO CONDORI QUISPE**

Jefe de la Dirección General de Administración

Correo : [diga@unfv.com.pe](mailto:diga@unfv.com.pe)

Presente.-

**Asunto:** Aprobación de Anexo 05 - Solicitud de  
Modificación del Cuadro Multianual de  
Necesidades

**Referencia:** MEMORANDO N° 026-2024-DIGA-UNFV

Es grato dirigirme a usted para saludarlo muy cordialmente y a la vez, en atención al documento de la referencia, se remite la aprobación de ANEXO N° 05: SOLICITUD DE MODIFICACIÓN DEL CUADRO MULTIANUAL DE NECESIDADES, sobre los requerimientos de las áreas usuarias que a continuación se detalla

N°	NT	Área Usuaría	Descripción del Bien / Servicio	Clasificador de gasto	Anexo 05 N°	Anexo 06 N°	Modif	Cant Total	Valor Total S/.
01	20585	OCGTI	Servicio de elaboración de informe técnico del sistema eléctrico y subestación	23.29.11	306	204	inclusión		4,000
02	13014	VRIN	Publicación de revista Use of Digital Tools (Wikihouse System) in Multi-Local Social Housing	23.22.41	301	205	inclusión		15,200
03	15824	VRIN	Publicación de revista Transportation system and the improvement of urban vehicular 3 flow in the district of Huánuco-Perú 2022	23.22.41	297	207	inclusión		11,400
04	15127	FAU	Equipo para aire acondicionado portátil de 15000 btu	26.32.91	278	203	inclusión	5	
05	15280	OASG	Adq herramientas para pintados aulas - predios UMTS - OASG - UNFV	23.199.199 23.199.199 23.199.11 23.199.11	312	206	inclusión	100 30 60 45	
6	18687	OASG	Acondicionamiento de archivos móviles locais SL014	2.3.24.21	318	208	inclusión		171,000.01
7	7648	EU	Mantenimiento Máquinas de Imprenta – E. U	2.3.24.71	302 304 303 305	215 214 213 212	inclusión		4,978.00 4,374.00 5,962.00 2,945.00
8	20308	BC	Servicio de suscripción a base de datos de publicaciones académicas y científicas	2.3.27.499	62	216	inclusión		335,900.00
9	20662	EU	Servicio de mantenimiento correctivo de la máquina laminadora - marca LH	2.3.24.71	309	211	inclusión		3,383.00



**UNIDAD DE CONTRATACIONES Y SERVICIOS BASICOS**

*"Año del Bicentenario, de la consolidación de nuestra Independencia, y de la conmemoración de las heroicas batallas de Junín y Ayacucho"*

			ELECTRONIC						
10	20663	EU	Servicio de Mantenimiento Correctivo de la Máquina ATF-Marca DAVIDSON 701	2.3.24.71	308	210	inclusión		5,922.00
11	21807	OI	Compra de tóner de impresión kyocera cod. ref. TK 6347 negro	2.3.15.12	326	209	inclusión	2	
12	16420	IREDA	Adquisición de buzos para delegaciones deportivas UNFV	2.3.12.11	319	219	exclusión	50	
13	09580	FIC	Contratación por Locación de Servicios	232911	227	217	Inclusión		7,200.00
14	022224	UMTS - OASG	Contratación por Locación de Servicios						
			NARREA CHAMAN JORGE LUIS		341				5,400.00
			RIVERA GUTIERREZ LUIS MIGUEL		342				4,500.00
			RUIZ PACHECO BRYAN CARLOS		343				3,600.00
			DE LA CRUZ QUISPE MARIO JAVIER	232911	344	218	Inclusión		4,500.00
			VASQUEZ HURTADO JUAN CARLOS		345				6,000.00
			BUENALAYA AQUINO EDGAR		346				6,000.00
15	022224	UCSB - OASG	Contratación por Locación de Servicios de BONIFACIO CHAVEZ NELSON ANDRE	232911	348	220	Inclusión		15,000.00
16	022224	UCSB - OASG	Contratación por Locación de Servicios de BEJAR ATOCHE YOLANDA DE LAS NIEVES	232911	348	221	Inclusión		15,000.00

Por consiguiente y a fin de continuar con la atención del expediente, se remite los ANEXO N° 06: APROBACIÓN DE MODIFICACIONES AL CUADRO MULTIANUAL DE NECESIDADES, generados a partir de los Anexos N° 05 solicitado por las áreas usuarias mencionadas, **para su aprobación**, y así poder remitir a las áreas usuarias para conocimiento y fines pertinentes.

Sin otro particular, aprovecho la ocasión para renovar las muestras de mi especial consideración y estima personal.

Atentamente,



**Bach. MANUEL ORTIZ CHÁVEZ**

Jefe

Unidad de Contrataciones y Servicios Básicos

V°B°

**LIC. JULIO GREGORIO TALLA RAMOS**

Jefe

Oficina de Abastecimiento y Servicios Generales

NT: 20585, 13014, 15824, 15127, 15280, 18687, 7648, 20308, 20662, 20663, 21807, 16420, 09580, 022224

MJOCH/nbch

ANEXO N° 06: APROBACIÓN DE MODIFICACIONES AL CUADRO MULTIANUAL DE NECESIDADES N° 00000205

UNIDAD EJECUTORA : 001 UNIVERSIDAD NACIONAL FEDERICO VILLARREAL  
NRO. IDENTIFICACIÓN : 000102

Fecha de Solicitud	N° de Solicitud de Modificación	Código Ítem N.-	Descripción del Ítem	Unidad de Medida	CANTIDAD Y/O VALORES			
					EXCLUSIÓN		INCLUSIÓN	
					Cantidad Total	Valor Total S/	Cantidad Total	Valor Total S/
102.04.03.1 - Instituto Central De Gestión De La Investigacion- Vrin								
14/03/2024	0000000301	150100020007	PUBLICACIONES DE ARTÍCULOS CIENTÍFICOS EN REVISTA INTERNACIONAL	Servicio	0.00	0.00	0.00	15,200.00

- 1/ La información registrada en el presente Anexo corresponde a campos mínimos y obligatorios que pueden ser ampliados por la Entidad del Sector Público u organización de la entidad.
- 2/ La información registrada en los campos de "exclusión" e "inclusión" considera la cantidad y/o valor acumulado de todos los años de la programación.
- 3/ El campo de "cantidad total" se completa solo en el caso de bienes.
- 4/ La presente información tiene carácter de Declaración Jurada; por lo que, en señal de conformidad y en representación de la Entidad del Sector Público u organización de la entidad, se suscribe:



Firma 1: Responsable del Área involucrada en la gestión de la CAP

Firma 2: Titular de la Entidad u Organización de la entidad, o a quien se hubiera delegado dicha facultad



INSTITUTO CENTRAL DE GESTIÓN DE LA INVESTIGACIÓN

“Año del Bicentenario, de la consolidación de nuestra Independencia,  
y de la conmemoración de las heroicas batallas de Junín y Ayacucho”

Lima, 14 de marzo del 2024

Oficio N° 078-2024-OPI-ICGINV-VRIN-UNFV.

**Lic. JULIO TALLA RAMOS**

Jefe de la Oficina de Abastecimiento y Servicios Generales.

Presente. -

**ASUNTO:** FINANCIAMIENTO DE ARTÍCULO CIENTÍFICO.

Tenemos a bien dirigirnos a usted para saludarlo cordialmente y a la vez remitir el expediente de requerimiento para FINANCIAMIENTO DE ARTÍCULO CIENTÍFICO, la misma que necesita ser aprobada por la oficina de Abastecimiento y la posterior autorización de la DIGA, para este efecto se adjunta el Anexo N° 05: Solicitud de Modificación del Cuadro Multianual de Necesidades N° 000301.

Cumplido el trámite respectivo, solicitamos devolver el expediente para continuar con la gestión de financiamiento del artículo: Use of Digital Tools (Wikihouse System) in Multi-Local Social Housing.

Esta publicación se financia con cargo a la actividad financiada con recursos ordinarios (SUBVENCIÓN DE PAGO POR CARGO DE PROCESAMIENTO DE ARTÍCULOS EN REVISTAS DE IMPACTO).

Sin otro particular es propicia la oportunidad para renovarle las muestras de mi especial consideración y estima.

Atentamente,



Firmado digitalmente por:  
MONROY CORREA GRACIELA MARTINA  
FIR 09715476 hard  
Motivo: Soy el autor del documento  
Fecha: 14/03/2024 12:52:36-0500

**Dra. Graciela Martina Monroy Correa**  
Jefa Oficina de Proyectos de Investigación



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LIVIA SEGOVIA JOSE HECTOR  
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**DR. JOSE HECTOR LIVIA SEGOVIA**  
Director del Instituto Central  
de Gestión de la Investigación

Adj.: 46 folios

NT: 013014

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Total S/

15,200.00



ANEXO N° 03: Cuadro Multianual de Necesidades - Servicios - Fase de Consolidación y Aprobación  
(Actualizado en atención al PIA)

UNIDAD EJECUTORA : 001 UNIVERSIDAD NACIONAL FEDERICO VILLARREAL  
NRO. IDENTIFICACIÓN : 000102  
CENTRO DE COSTO : 102.04.03.1 - INSTITUTO CENTRAL DE GESTIÓN DE LA INVESTIGACION- VRIN

					CANTIDAD Y/O VALORES															
FF/Rb		Clasificador de Gastos	Actividad Operativa	Meta	2024				2025				2026				2027			
Código del Ítem	Tipo	Descripción del Ítem	Unidad de Medida	Precio Unitario	Semestre 1		Semestre 2		Semestre 1		Semestre 2		Semestre 1		Semestre 2		Semestre 1		Semestre 2	
					Cantidad	Valor Total S/	Cantidad	Valor Total S/	Cantidad	Valor Total S/	Cantidad	Valor Total S/	Cantidad	Valor Total S/	Cantidad	Valor Total S/	Cantidad	Valor Total S/		
PROGRAMACIÓN: C.M.N.					1,314,633.98		36,920.02		75,339.00		38,625.00		76,482.00		39,768.00		0.00			
2-09 RECURSOS DIRECTAMENTE RECAUDADOS					38,714.00		3,000.00		39,714.00		3,000.00		39,714.00		3,000.00		0.00			
Meta: 0024 - INVESTIGACION CIENTIFICA Y TECNOLOGICA					38,714.00		3,000.00		39,714.00		3,000.00		39,714.00		3,000.00		0.00			
Actividad Operativa: C0369 - ACTIVIDADES ADMINISTRATIVAS QUE APOYAN EL DESARROLLO DE LAS ACTIVIDADES ACADÉMICAS					8,000.00		3,000.00		8,000.00		3,000.00		8,000.00		3,000.00		0.00			
2.3. 2 4. 7 1 DE MAQUINARIAS Y EQUIPOS					8,000.00		3,000.00		8,000.00		3,000.00		8,000.00		3,000.00		0.00			
60100001000	S	MANTENIMIENTO CORRECTIVO DE EQUIPO DE AIRE ACONDICIONADO	SERVICIO		0.00		3,000.00		0.00		3,000.00		0.00		3,000.00		0.00			
60350001005	S	MANTENIMIENTO PREVENTIVO DE FOTOCOPIADORA	SERVICIO		5,000.00		0.00		5,000.00		0.00		5,000.00		0.00		0.00			
60350001007	S	MANTENIMIENTO CORRECTIVO DE SURTIDOR DE AGUA ELECTRICO - DISPENSADOR ELECTRICO	SERVICIO		3,000.00		0.00		3,000.00		0.00		3,000.00		0.00		0.00			
Actividad Operativa: C0372 - EVENTOS DE INVESTIGACIÓN					12,714.00		0.00		13,714.00		0.00		13,714.00		0.00		0.00			
2.3. 2 9. 1 1 LOCACION DE SERVICIOS REALIZADOS POR PERSONAS NATURALES RELACIONA					12,714.00		0.00		13,714.00		0.00		13,714.00		0.00		0.00			
07110043029	S	SERVICIO DE ATENCIÓN Y CONTROL DE CAPACITACIONES, EVENTOS Y TALLERES	SERVICIO		12,714.00		0.00		13,714.00		0.00		13,714.00		0.00		0.00			
Actividad Operativa: C0373 - PROYECTOS DE INVESTIGACIÓN CON INCENTIVO					18,000.00		0.00		18,000.00		0.00		18,000.00		0.00		0.00			
2.3. 2 9. 1 1 LOCACION DE SERVICIOS REALIZADOS POR PERSONAS NATURALES RELACIONA					18,000.00		0.00		18,000.00		0.00		18,000.00		0.00		0.00			
07110038851	S	SERVICIO DE JURADO EVALUADOR DE PROYECTOS DE INVESTIGACIÓN	SERVICIO		18,000.00		0.00		18,000.00		0.00		18,000.00		0.00		0.00			
TOTAL GENERAL S/					1,314,633.98		36,920.02		75,339.00		38,625.00		76,482.00		39,768.00		.00			

La presente información tiene carácter de Declaración Jurada, por lo que en señal de conformidad y en representación del área usuaria se suscribe:



Firma: Responsable del área usuaria



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## Article

# Use of Digital Tools (Wikihouse System) in Multi-Local Social Housing

Doris Esenarro <sup>1,\*</sup>, Emerson Porras <sup>2,3</sup>, Hardy Ventura <sup>2</sup>, Julio Figueroa <sup>2</sup>, Vanessa Raymundo <sup>2,3</sup> and Lorena Castañeda <sup>2,3</sup>

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<sup>2</sup> University Ricardo Palma, Santiago de Surco 15039, Peru; emerson.porras@urp.edu.pe (E.P.); hardy.ventura@urp.edu.pe (H.V.); juliocastaneda@urp.edu.pe (J.F.); 202112586@urp.edu.pe (V.R.); lorena.castaneda@urp.edu.pe (L.C.)

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**Abstract:** The primary objective of this study is to formulate a comprehensive digital and physical model, at a scaled level, for a social housing unit utilizing the open-source Wikihouse system. The construction industry is currently grappling with the dual challenges of a real estate crisis and climate change. In response to this scenario, the integration of industrialized methods in construction processes is advocated to enhance the overall quality of the end product, streamline construction timelines, and curtail production costs. The algorithm developed for this purpose leverages Rhino and Grasshopper programs, thereby optimizing material efficiency when compared to traditional individual pieces. Noteworthy among the features of the Wikihouse system is its remarkable versatility, allowing implementation in diverse locations. This flexibility stems from its efficient assembly characteristics, which liberate it from the constraints of rigid modular structures, contributing significantly to architectural design flexibility. The paramount finding of this research is the demonstrated efficiency of the proposed system, requiring 44% less time compared to conventional construction practices and exhibiting a commendable 29% reduction in costs. These outcomes position the Wikihouse-based approach as an appealing and competitive alternative within the real estate sector.

**Keywords:** modular; open-source; digital tools; sustainable construction; Wikihouse

**Citation:** Esenarro, D.; Porras, E.; Ventura, H.; Figueroa, J.; Raymundo, V.; Castañeda, L. Use of Digital Tools (Wikihouse System) in Multi-Local Social Housing. *Sustainability* **2024**, *16*, x. <https://doi.org/10.3390/xxxxx>

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## 1. Introduction

The construction industry in Peru is currently immersed in a complex scenario marked by challenges stemming from the real estate crisis and climate change [1]. The main drivers of climate change are human activity and high levels of greenhouse gas emissions in the atmosphere [2]. Moreover, it is primarily attributed to the construction sector's activity [3]. It is estimated that by the year 2021, this sector will consume about 40% of the available energy worldwide, contributing to approximately one-third of global greenhouse gas emissions during the construction and operation of buildings [4,5]. Based on this, industry efforts are focused on reducing energy demand and the environmental impact of buildings, improving the design phase, and implementing energy conservation measures [6].

The real estate crisis has impacted financial stability and investment in projects, generating uncertainty in the market [7]. On the other hand, climate change presents additional challenges, as Peru experiences extreme climatic phenomena, such as floods and droughts, directly affecting the planning and execution of construction projects [8,9]. The need to adopt more sustainable and resilient practices has become imperative, with the

industry facing the task of finding innovative solutions to address the real estate crisis while strengthening the resilience of constructions against the impacts of climate change in the Peruvian context [10,11]. This scenario demands integrated strategies and collaboration among various industry stakeholders to effectively address these challenges and build a more sustainable sector adapted to changing climatic conditions.

In Peru, around 10 million individuals, equivalent to approximately one-third of the total population of the country, reside in informal urban settlements characterized by a lack of essential services, such as infrastructure, public spaces, and adequate equipment, in addition to deficiencies in urban planning design [12]. This figure represents approximately half of the urban population and, in some cities in the Peruvian Amazon region, the proportion exceeds 80% [13]. It is evident that the urban population's growth and the construction rate surpass the state's capacity to develop cities, highlighting significant historical deficiencies in the urban planning process and approach [14].

In recent years, technological progress has enabled the automation of processes in various economic sectors. The construction industry has not been immune to this transformation, widely adopting digital tools in its environment. This change began in the 1990s with the introduction of CAD version 1.0 software, replacing manual methods of drawing plans. Likewise, project management has evolved, gradually incorporating collaborative work principles, displacing traditional management [15].

The use of digital tools in the field of architecture is currently necessary for their application in the development of various projects, such as digital fabrication, through a set of techniques that use machines to create physical objects directly from computational designs [16]. Therefore, promoting their application in the development of architectural concepts is sought [17]. Knowledge of these tools is essential for future interior designers and architects to engage with various techniques and technologies during their education, making it a priority to experiment with a wide variety during the teaching process [18]. This application is implemented in different systems, where the representation of complex architectural elements has been significantly improved thanks to digital tools, allowing greater precision and detail in their representation [19]. Among the most widely used modular construction systems supported by digital tools is the prefabricated system, which is a method of producing elements or parts of a construction on an industrial scale, using environmentally unfriendly materials, such as concrete, which is estimated to be responsible for 90% of CO<sub>2</sub> emissions in industrial processes [20]. This system prioritizes cost efficiency in design and construction, and its availability is limited to large cities and surrounding areas, excluding more remote populations where access is limited [21].

Within prefabricated systems, the PPVC steel modules (Prefabricated and Finished Volumetric Construction) stand out, which propose bioclimatic strategies, such as the installation of thermal solar collectors on the module and structural resistance at great heights; however, this system entails a cost of 21,260.00 euros for a built area of 25 m<sup>2</sup>. Additionally, the system considers factors such as costs, labor, time, and pollution [22].

Another prefabrication system on a smaller scale, used for the development of this research, is Wikihouse. It operates with a system for the creation of plywood modules manufactured through digital technology and open-source code. Created by Alastair Parvin and Nick Ierodiaconou in 2011, they claim that this system is efficient, robust, and carbon-neutral [23]. Additionally, despite its application being limited to orthogonal geometry and the need to create new pieces to fit the design models and regulations of a specific location [24], the system has been recognized for its fundamental role in the development and execution of buildings using subtractive digital fabrication equipment [25]. Consequently, many modular projects remain in the conceptual stage due to the need for expensive licenses or permits for physical development. In this context, the presence of groups promoting the use of open-source software has facilitated cooperation and information exchange. The use of these open-source software tools has also had a positive impact on reducing license costs, contributing to the overall cost reduction of solutions [26].

On the other hand, each location has a set of requirements and design strategies for the development of a proposal. In this sense, the Wikihouse system allows mass production through the development of an algorithm created by each serving entity of the open-source system. This open-source software creation culture fosters online collaboration, the integration of diverse disciplines, the importance of practical experimentation, and informal approaches to knowledge creation, research, and innovation [27]. The research approach is based on the integration of two fundamental ideas: “coexistence” and “openness.” The purpose of this research is to delve into the relationship between these concepts and their connection to existing literature on “Global Design, Local Manufacturing” [28].

Regarding housing in Peru, it presents a series of challenges depending on the location, and often not receiving much attention when designing a proposal for optimal user comfort. In this sense, the system can develop short-term modular housing production based on parameterization that uses comfort strategies [29]. This comfort is achieved through principles that prioritize the conscious use of materials [30].

Modular developments in these systems are created through similar pieces that can be assembled into a composition. There are different types or, alternatively, if we use the theory of polyominoes, which is based on the use of the cube as the main element, we are already establishing a composition method. This is because these forms have a modular structure that allows the creation of interesting three-dimensional solid spaces [31], in addition to the implementation of mechanisms related to the use of wind turbines in architectural structures and hybrid systems to create energy conversion modules [20]. One of the benefits of using this system is its modularity, which employs a parametric design methodology that discards any form that does not fit predefined parameters and, instead, focuses on developing forms that meet those criteria. This design approach provides several advantages compared to traditional methods, which are often more linear and systematic, such as concrete and steel, which have a significant environmental impact. By reducing the time needed to create models, more time can be dedicated to exploring and experimenting with the environmental comfort challenges presented by each intervention site, leading to a higher degree of refinement in the desired shapes and designs [32]. These designs focus on enabling open-source strategies in architecture [33].

Like the systems used in different specialties, designing based on modular forms is an application that seeks to optimize and improve design in contemporary architecture, both locally and globally. It requires designers to adopt an innovative approach when addressing projects, paying special attention to the concept of pragmatism [34]. The location of a housing project using the Wikihouse system has the necessary potential to meet the physical needs and conditioning requirements of the user according to the environment and climate of its location. In terms of housing typology, due to its flexibility, it can offer greater possibilities for design strategies and can adapt and leverage different ecosystems [35].

The application of digital tools, such as the Wikihouse system, in multi-local social housing has significant relevance for addressing and reducing the housing crisis in Peru. The use of digital technologies in the design and construction of houses allows greater efficiency in processes, which can result in faster and more affordable production of housing units. The Wikihouse system, being an open-source platform that facilitates digital manufacturing and the construction of modular homes, offers the possibility of adapting and customizing designs to the specific needs of marginalized and low-income communities [36,37]. The implementation of these digital tools in multi-local social housing not only streamlines the construction process but can also contribute to cost reduction, making housing more accessible for populations facing economic difficulties [38]. Furthermore, the flexibility and adaptability of the Wikihouse system allow greater versatility in housing construction that adjusts to the specific conditions of informal settlements, thus contributing to improving the quality of life of communities affected by the housing crisis in the country.

Some benefits provided by digital manufacturing include adaptability or easier implementation in different contexts due to the modular design, and the ability to be built with materials accessible worldwide, such as phenolic plywood.

- It does not require specialized labor for construction, nor sophisticated tools.
- Connection are made through snap fits without the need for additional fasteners such as nails or screws.
- It is easy to transport and compatible with any type of foundation.
- In addition to generating fewer emissions in its production than other materials, wood actually captures and stores carbon from the atmosphere while in use; this is why it is called carbon-negative.
- On the other hand, its design considers a 30 cm space for thermal insulation that can be used depending on the climatic conditions of the proposed location.

The socio-environmental benefits derived from the use of parametric design tools, software-based artificial intelligence, specifically with tools like Grasshopper and the Wikihouse system, are diverse. Software-based artificial intelligence, like Grasshopper 1.0.0007, significantly improves design efficiency, allowing faster and more accurate planning of architectural projects. The software contributes to the optimization of designs, reducing the use of materials in the manufacturing of modular parts. This has a direct impact on resource conservation and the mitigation of material shortages. The Wikihouse system stands out for using eco-friendly materials, such as wood. This not only contributes to environmental sustainability but also creates a favorable environment for the surroundings and users. The implementation of technologies like Grasshopper and systems like Wikihouse can reduce energy consumption in construction, thus contributing to energy efficiency and the reduction of environmental impact. The efficiency in design and manufacturing, facilitated by artificial intelligence parametric design tools like Grasshopper and the Wikihouse system, leads to a reduction in costs associated with material manufacturing and processing, making architectural projects more economically accessible.

Research on the use of the Wikihouse digital tool in social housing can open various directions and future applications. Here are some possible areas that could be explored as a continuation of the research:

- **Design Optimization:** Investigate ways to further optimize the design of houses using Wikihouse, considering aspects such as energy efficiency, adaptability to different climates, and ergonomics.
- **Long-Term Social and Community Impact:** Evaluate the long-term social and community impact of houses built with Wikihouse. This could include studies on resident satisfaction, community strengthening, and the impact on social mobility.
- **Sustainability and Innovative Materials:** Explore additional options to improve the sustainability of the Wikihouse system, such as integrating innovative and eco-friendly materials, as well as the possibility of material recycling.

These future directions and applications can contribute to expanding the understanding and positive impact of Wikihouse implementation in the field of social housing, addressing specific challenges and leveraging opportunities for further improvement of efficiency, sustainability, and accessibility in affordable housing construction.

Based on recent advances in parametric design and digital manufacturing tools, Wikihouse and OSE Microhouse projects seek to create sustainable, efficient, and self-sufficient construction structures. They also employ various technologies for the construction of their main components [39]. These constructions incorporate a modular design that enables the creation of spaces tailored to user needs and the specific climatic conditions of their location. Versatility lies in their ability to rotate freely without compromising functionality, meaning that the only limitation to using the system in different places and achieving adaptation to the environment lies in the dimensions of the available land [39].

The positive impact of open-source software on reducing license costs is clearly demonstrated in the context of WikiHouse, an innovative platform in the field of architecture and construction. Distancing itself from traditional proprietary software with high license costs, WikiHouse adopts an open and collaborative model, which not only makes design and construction more accessible but also significantly reduces overall project costs. Building a 44 m<sup>2</sup> house with WikiHouse and second-hand materials can cost approximately 38,000 euros, much less than traditional methods. This cost efficiency is largely due to the elimination of design software license expenses, allowing for a better distribution of the budget for quality materials and energy efficiency [40]. Moreover, WikiHouse encourages a culture of collaboration and knowledge-sharing in the design and construction community. Users can adapt designs to their needs and share their modifications, thus promoting continuous innovation and improvements in designs. This practice not only accelerates the development of more efficient and sustainable solutions but also builds a community of practice where knowledge and experiences are freely shared.

Another study complements this view, showing how visual algorithmic modeling in Grasshopper applied to WikiHouse can generate a wide range of spatial and formal solutions, thereby expanding design possibilities and applications in temporary and modular architecture. Finally, WikiHouse has a positive impact on sustainability and energy efficiency, reducing the carbon footprint and energy consumption compared to conventional construction systems [41].

In summary, the aim of this research is to put forth the design of a housing prototype employing modular techniques and the open-source WikiHouse system. This encompasses a consideration of economic variables and user comfort through the implementation of design strategies and algorithms utilizing digital tools.

## 2. Materials and Methods

### 2.1. Methodological Phase

This research has an experimental nature. It begins with the compilation of information from scientific articles, followed by the identification of data related to the topic and its proper classification. Finally, it allows for the conduct of experimental tests, both physical and digital, of a proposal that meets the desired objective.

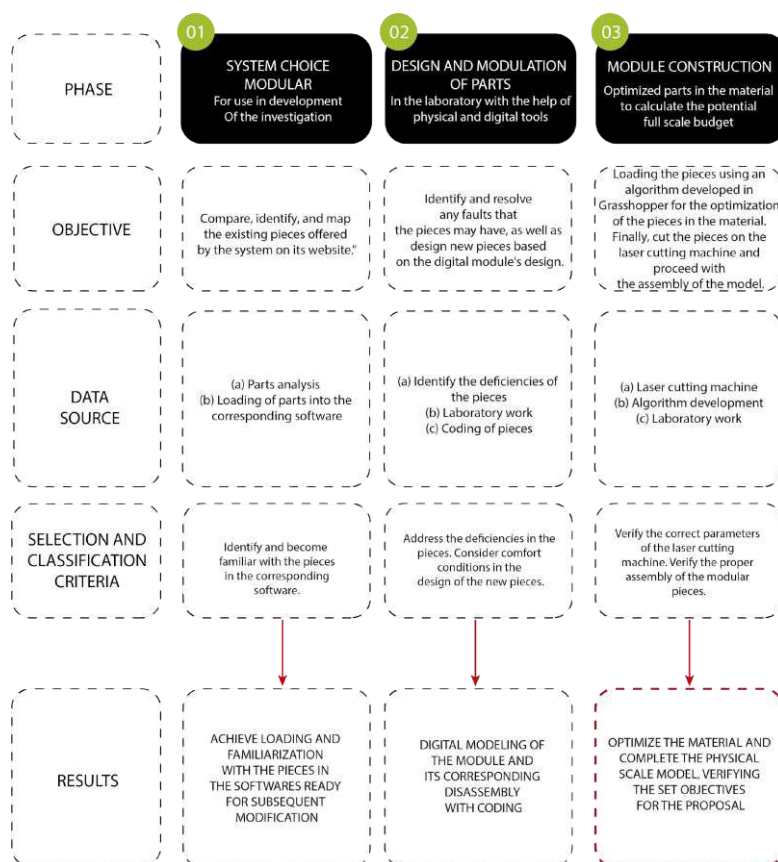
The algorithm played a crucial role in optimizing the efficiency of material usage. One of its specific functions was the intelligent organization of cutting pieces, achieved through an advanced 'nesting' process. Nesting is a computational technique used to arrange two-dimensional shapes in a limited space, in this case the material surface, in a way that minimizes waste. This approach is particularly relevant in the context of WikiHouse, where component information is provided in 3D and 2D formats.

Adapting this information for CNC laser cutting instead of CNC routers was a significant challenge. It required not only readjusting the dimensions and arrangement of pieces but also optimizing the cutting process for a different type of machine. The adjustable parameters of the algorithm allowed for modification of design information, from geometry to specific details for physical prototype production.

The algorithm not only maximized material utilization through effective nesting but also provided flexibility in parameter adjustments. This allowed adaptation of the design for different types of machinery and materials, thereby increasing project efficiency and sustainability. Material waste reduction is not only economically advantageous but also contributes to a more sustainable and environmentally conscious design practice. Additionally, the ability to quickly adapt the design to different production methods demonstrates the versatility and power of the algorithmic approach in digital manufacturing and architectural design.

Figure 1 presents each phase developed throughout the research process, from the selection of the modular system to the creation of a scale model. The aim of this model is

to verify economic feasibility and assess efficiency in terms of user comfort. The phases include:



**Figure 1.** Methodological phase.

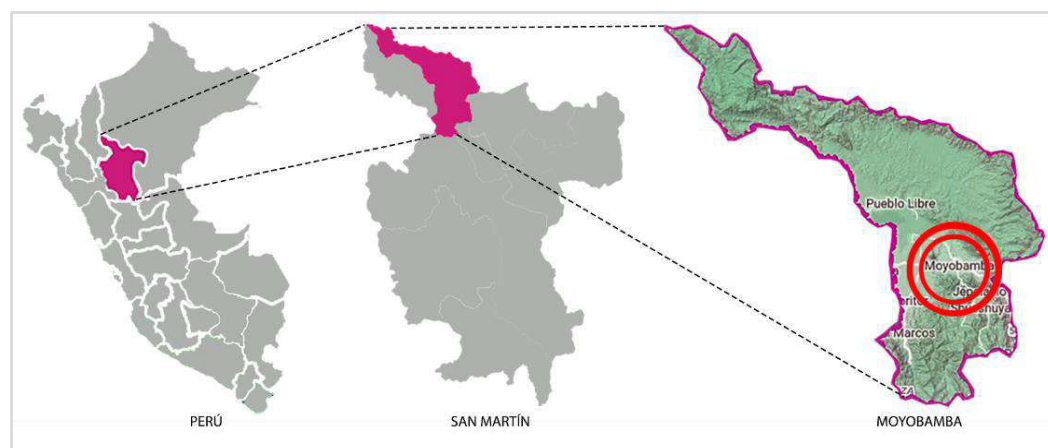
- Phase 1: Selection of the Modular System. The process began with an analysis to select various modular systems. During this evaluation, various factors were considered, such as software compatibility with the system, costs and materials needed for construction, circular economy considerations, and the environmental impact associated with the research outcome. The chosen system for the research was Wikihouse. To implement this, a detailed analysis of its components (piece connection model and assembly order for an orderly assembly) was conducted, along with familiarization with them, and then loading and modifying these pieces in the corresponding software.
- Phase 2: Design and Modulation of Pieces. In this stage, the search for the ideal location to develop the proposal started. This location had to meet specific criteria, such as varied climatic conditions, geographical isolation limiting access to conventional construction materials, and the availability of wood as the main raw material for the Wikihouse system. Simultaneously, progress was made in designing the housing model, incorporating new pieces. These not only met the rigorous structural standards of the Wikihouse system but also aimed at generating and developing environmental strategies that preserve the use of materials and benefit the user. These strategies were conceived to be comprehensively utilized in the module based on the final algorithm of the project.
- Phase 3: Construction of the Module. In this final phase, an algorithm was designed to facilitate the loading of the final pieces, which played a crucial role in both the laser cutting process and the construction of the physical model at scale. This algorithm was developed using Rhino and Grasshopper programs, which sorted and categorized modular pieces, considering indicators such as area, piece shape, and scale,



achieving notable efficiency in material utilization. Additionally, an estimated projection of both the required material quantity and the associated cost for the construction of the real-scale housing module was generated. The housing prototype will be made using wood due to multiple factors, such as availability and accessibility, as wood is a common and accessible construction material in many regions worldwide. This facilitates its acquisition for self-construction projects in different places, due to its lightness and ease of handling, as it is a lightweight material compared to others, like concrete or steel. This characteristic facilitates its manipulation during construction, especially in projects where active participation of individuals building their own homes is sought. Sustainability: If sustainably sourced from managed forests, wood contributes to the project's sustainability. Wood is a renewable resource, and its proper use can help reduce the ecological footprint of construction. Ease of cutting and assembly: Wood is a material that can be cut and worked with common tools, facilitating its use in self-construction projects where specialized construction skills are not required. Energy efficiency: Wood has natural thermal insulation properties, which can contribute to the energy efficiency of homes built with this material. Flexibility and design versatility: Wood is a versatile material that can adapt to various architectural designs.

## 2.2. Ubication

The location for the social housing prototype with the Wikihouse system was selected considering different ecosystems in the environment and the economic and social needs that the analyzed location may have [42]. Figure 2 shows the place designated for the development of the prototype was:

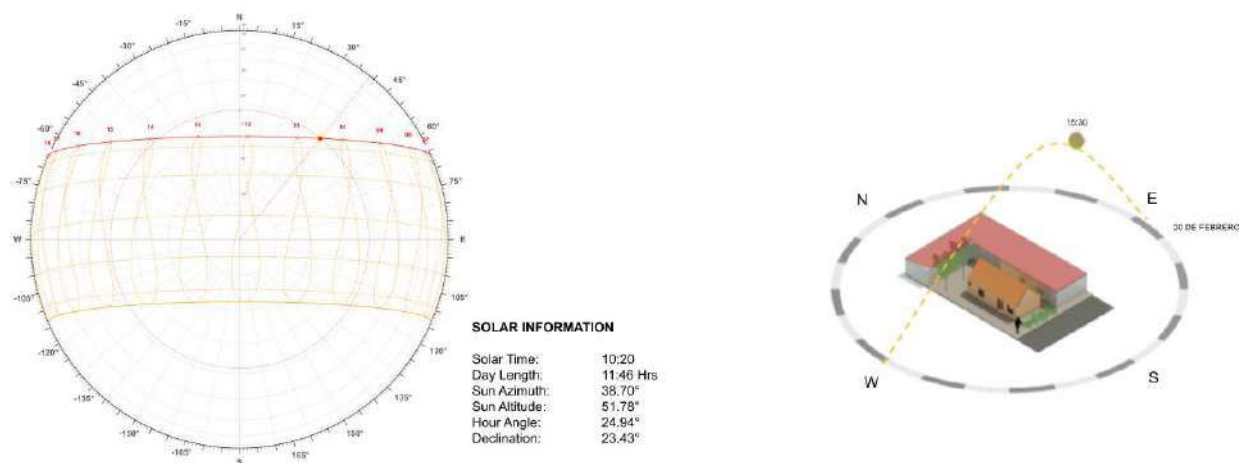


**Figure 2.** Place of study.

## 2.3. Climate

The city has a warm climate, moderately rainy with moderate temperature fluctuations. In the case of the solar chart analysis, it was found that the azimuth angle  $294.6^\circ$  and the elevation angle  $13.91^\circ$  indicate that the sunlight has a steeper slope [43].

Figure 3 represents the incidence of the solar path on the modular housing, taking into account the immediate surroundings.

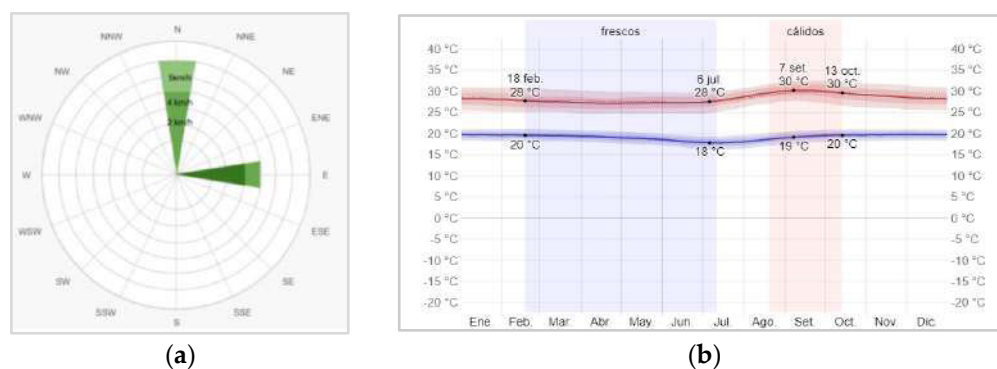


**Figure 3.** Solar chart of the city of Moyobamba.

#### 2.4. Winds and Temperature

The average wind speed per hour in Moyobamba does not vary considerably throughout the year and stays within a range of approximately 0.3 km–4.4 km per hour. The predominant wind direction in this region most frequently comes from the east for 5.9 months, from April 1st to September 28th, with a maximum percentage of 53% on August 1st. The wind most frequently comes from the north for 6.1 months, from September 28th to April 1st, with a maximum percentage of 64% on January 1st [22] (Figure 4a).

The cool season lasts 4.8 months, from February 18th to July 11th, and the average daily maximum temperature is below 28 °C. The coldest month of the year in Moyobamba is June, with an average minimum temperature of 18 °C and a maximum of 27 °C [42] (Figure 4b).



**Figure 4.** Wind Chart (a) and Temperature Chart (b).

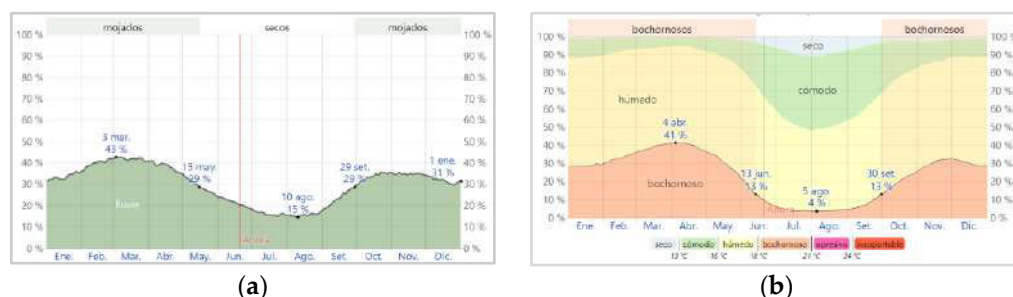
Figure 4 identifies image (a), which represents the incidence of winds in the study area with an average speed of 5 km/h. Furthermore, image (b) shows the maximum and minimum temperatures, which vary between 18 °C and 30 °C depending on the month.

#### 2.5. Precipitation and Humidity

The rainiest season lasts for 7.6 months, from September 29th to May 15th, with a probability greater than 29% of any given day being rainy. The month with the rainiest days in Moyobamba is March, with an average of 13.0 days with at least 1 mm of precipitation [42] (Figure 5a).

The wettest period of the year lasts for 8.4 months, from September 30th to June 13th, and during that time the comfort level is sultry, oppressive, or unbearable for at least 13%

of the time. The month with the sultriest days in Moyobamba is March, with 12.1 sultry days or worse [42] (Figure 5b).

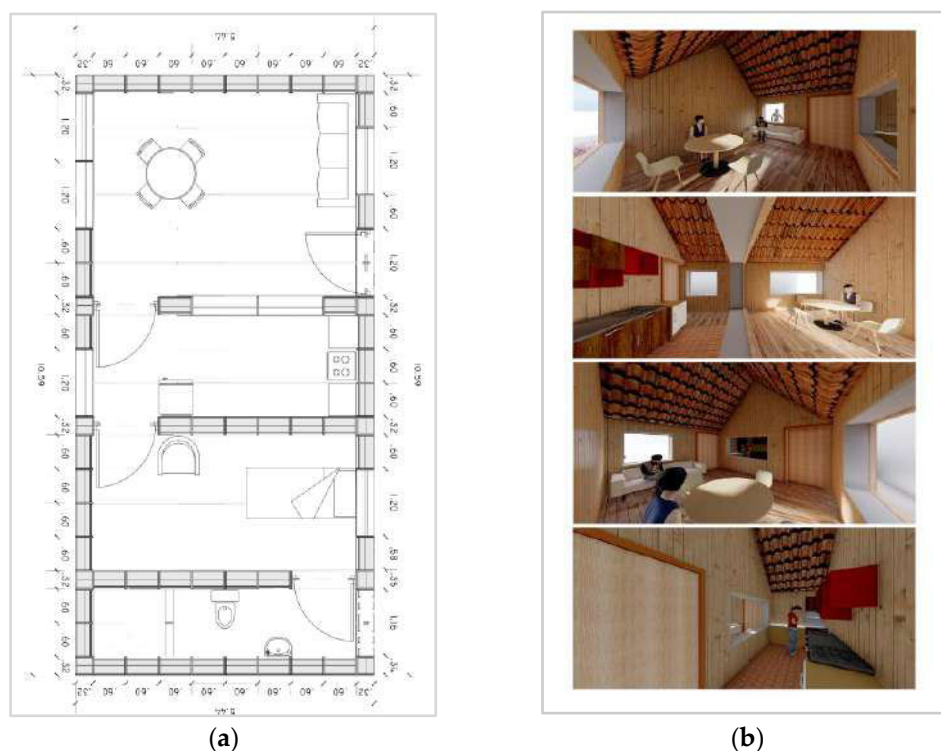


**Figure 5.** Precipitation Chart (a) and Humidity Chart (b).

### 3. Results

#### 3.1. Proposal

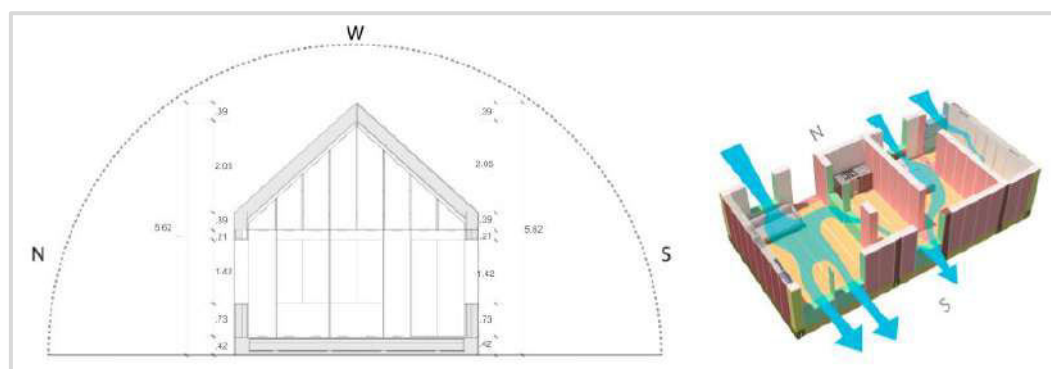
The digital proposal for the modular housing prototype through the Wikihouse system incorporates a space distribution adapted to the system and the spatiality intended to be achieved. (Figure 6)



**Figure 6.** Plan of the module (a) and Render (b).

#### 3.2. Climate Indicators

Rooms with only one window will have poor ventilation. In this case, designs are proposed with spaces adequately ventilated through cross-ventilation, promoting the circulation of fresh air from doors or windows on opposite sides to enhance user comfort. [44] (Figure 7).



**Figure 7.** Cross ventilation diagram in the modular house.

### 3.3. Economics Indicators

The 57.50 m<sup>2</sup> house consists of a series of modular pieces (Figure 8), which, when joined together, create the basic spaces for a home (living–dining area, kitchen, one bedroom, and a bathroom). The aim is to benefit the users and their immediate environment in various aspects, such as comfort, economy, simplicity, etc. [45].

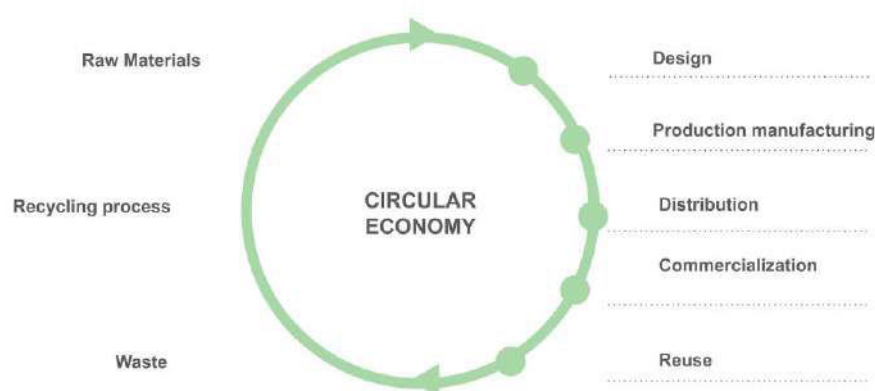


**Figure 8.** Identification of modular pieces in the model.

Figure 8 represents the identification of all modular components of the house.

Development with modular structures offers the advantage of adapting to user needs, and using wood, compared to materials commonly used in the area, such as steel or concrete, promotes greater integration of the circular economy, reducing environmental impacts, lowering energy consumption, and reducing the use of natural resources. Additionally, it allows for the restoration of natural capital and encourages regeneration for future reuse, bringing about a comprehensive change in construction design.

An inventory of the necessary pieces is prepared (Figure 9) for loading into the corresponding software, allowing for the determination of the material required for each corresponding modular piece number.

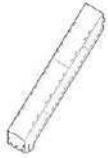


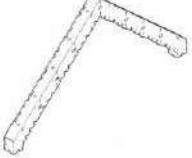


**Figure 9.** Identification of the modular pieces in the model.

In Figure 10, the breakdown of in-house manufacturing (b) is assessed and presented in relation to the pieces provided by the Wikihouse system (a).

NAME	Nº PARTS	
SK-BASE 1	15	
SK-BASE 2	5	
SK-SIDE WALLS	29	
SK-TYPE CORNER 1	4	
SK-TYPE CORNER 2	6	
SK-HIGH WINDOW (OWN DESIGN)	7	
SK-LOW WINDOW	1	
SK-SIDE CLOSURE	16	
SK-DOORS	4	
SK-CONEXIÓN TECHO A DOS AGUAS	5	
SK-GABLE ROOF	15	

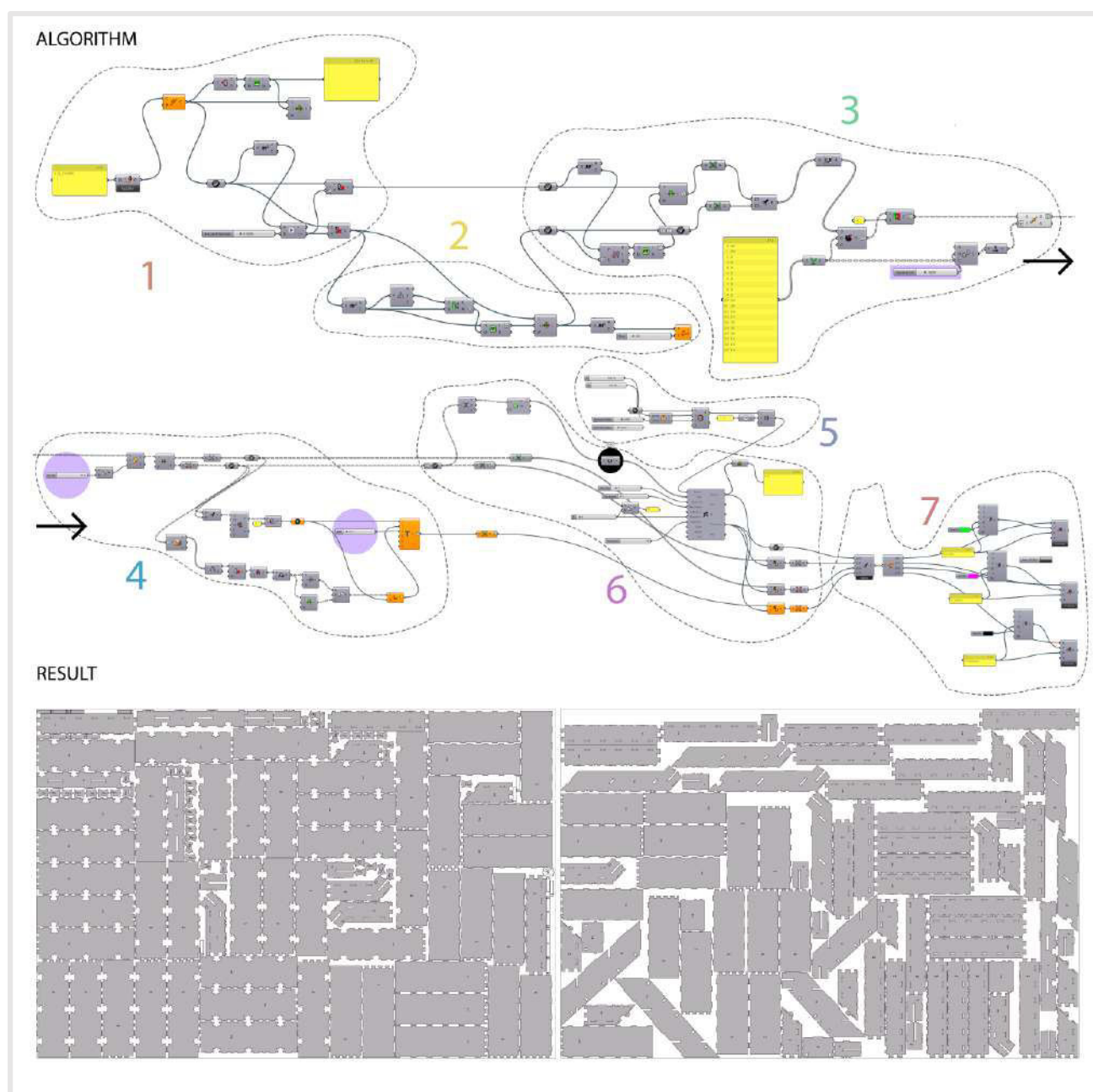
 <b>ROOF-M42</b> w5436 l600 h380 A 42 degree double-pitched roof end block that works with a 4.8 m internal span.	 <b>ROOF-S42</b> w4836 l600 h380 A 42 degree double-pitched roof end block that works with a 4.2 m internal span.
 <b>VERGE10-S</b> w4836 l318 h380 A 10 degree mono-pitched roof end block that works with a 4.2 m internal span.	 <b>VERGE42-L</b> w6036 l318 h380 A 42 degree double-pitched roof end block that works with a 5.4 m internal span.

(a)
(b)

**Figure 10.** Number of modular pieces by type (a) Modular pieces; (b) Source: Wikihouse.

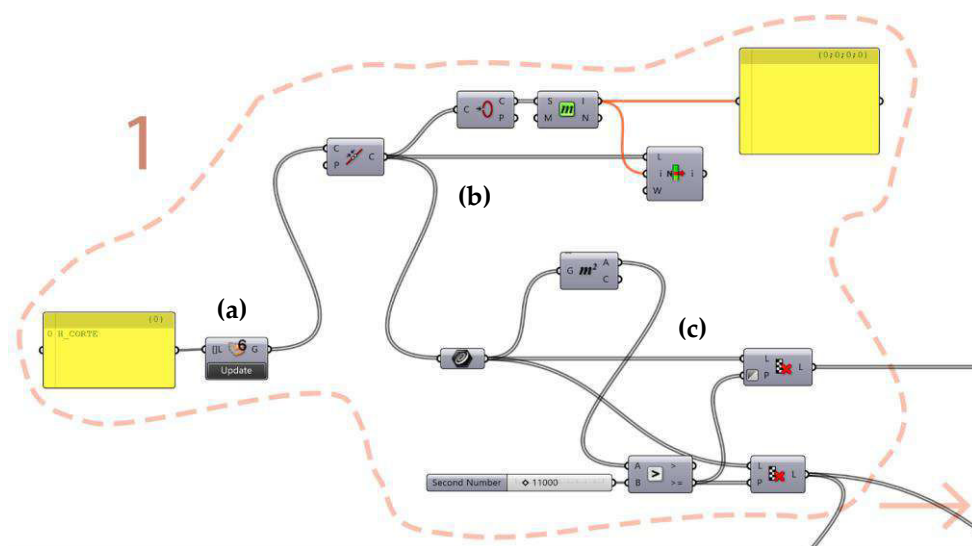
Figure 11 presents the final algorithm, which allows for the modification of indicators, such as scale, material dimensions, margin of error, minimum separation between pieces, laser cutting machine factor, etc. All these indicators enable the proper optimization of the pieces in relation to the laser cutting material. The algorithm is divided into seven development phases, which are as follows:





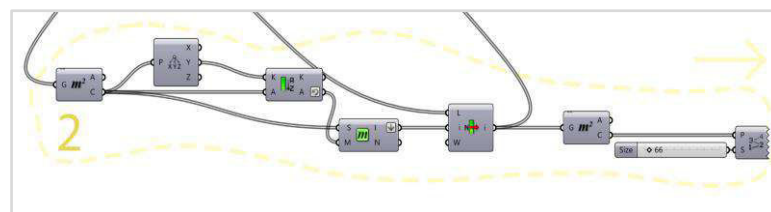
**Figure 11.** Graph of the use of the algorithm in the modular pieces of SK-TECHO A DOS AGUAS at a 1/10 scale on a 2 mm cardboard model measuring 965 × 665 mm.

Figure 12 represents Phase 1 of the algorithm, which allows for identification of the geometry of the modular pieces using the Elefront R6 plugin (a). After that, the area of each piece is calculated (b), and the external pieces are separated based on the area (c).



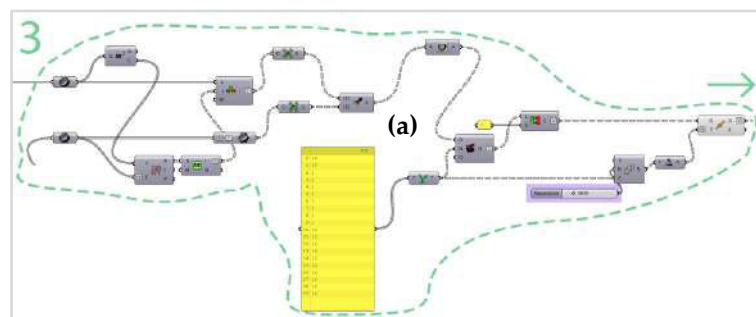
**Figure 12.** Phase 1 of the development of the algorithm for optimizing modular pieces in laser cutting material.

Figure 13 represents Phase 2 of the algorithm, which systematically identifies the areas of each piece and arranges them in ascending order from smaller to larger area.



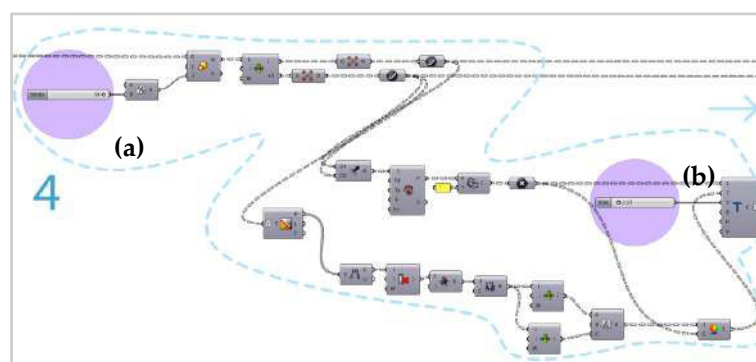
**Figure 13.** Phase 2 of the development of the algorithm for optimizing modular pieces in laser cutting material.

Figure 14 represents Phase 3 of the algorithm where, once the pieces are identified by their areas, the respective quantity needed for each piece is indicated (a), using the cutting plan table as a reference.



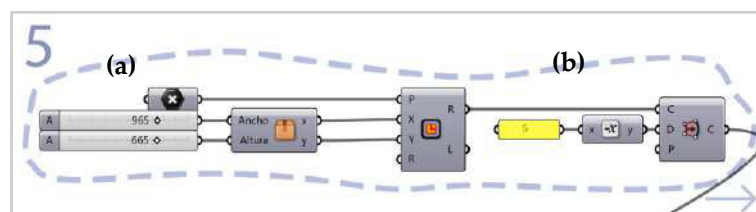
**Figure 14.** Phase 3 of the development of the algorithm for optimizing modular pieces in laser cutting material.

Figure 15 represents Phase 4 of the algorithm, where the scale is established for each piece (a). Subsequently, each piece is assigned a code in an orderly manner (b), facilitating the assembly of the model.



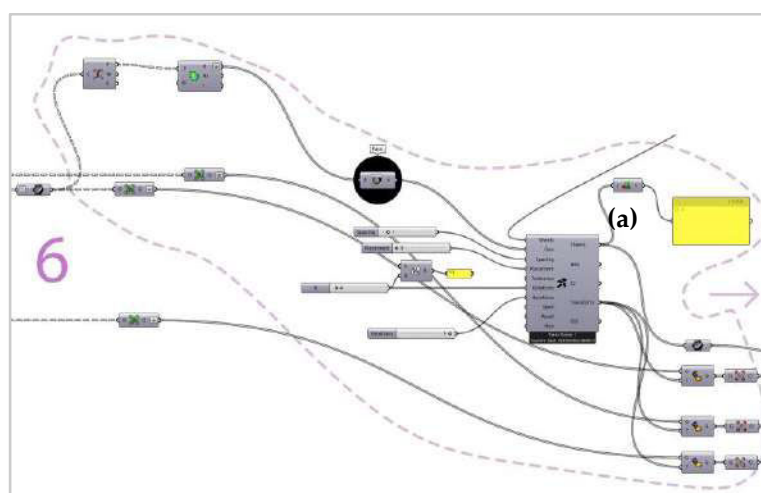
**Figure 15.** Phase 4 of the development of the algorithm for optimizing modular pieces in laser cutting material.

Figure 16 shows Phase 5 of the algorithm where the material dimensions are loaded (a), ensuring it does not exceed the maximum dimensions of  $1300 \times 900$  mm accepted by the laser cutting machine. Additionally, a margin of material utilization at the edges is established, expressed in millimeters (b).



**Figure 16.** Phase 5 of the development of the algorithm for optimizing modular pieces in laser cutting material.

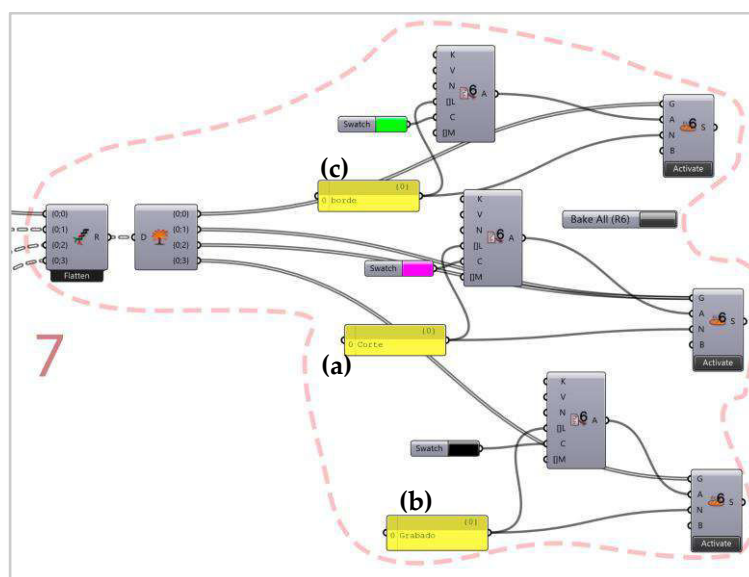
Figure 17 represents Phase 6 of the algorithm, where all the previous phases are loaded, allowing us to see the final result of the algorithm. The plugin used for this phase is Open Nest (a), which allows us to group all the previous actions. Some of the main actions of the plugin include organizing the pieces in the workspace according to their area and using them to arrange the codes of each piece.



**Figure 17.** Phase 6 of the development of the algorithm for optimizing modular pieces in laser cutting material.

Figure 18 represents the new layers assigned for laser cutting, identified by cut lines (a), engraving lines (b), and material edges (c).

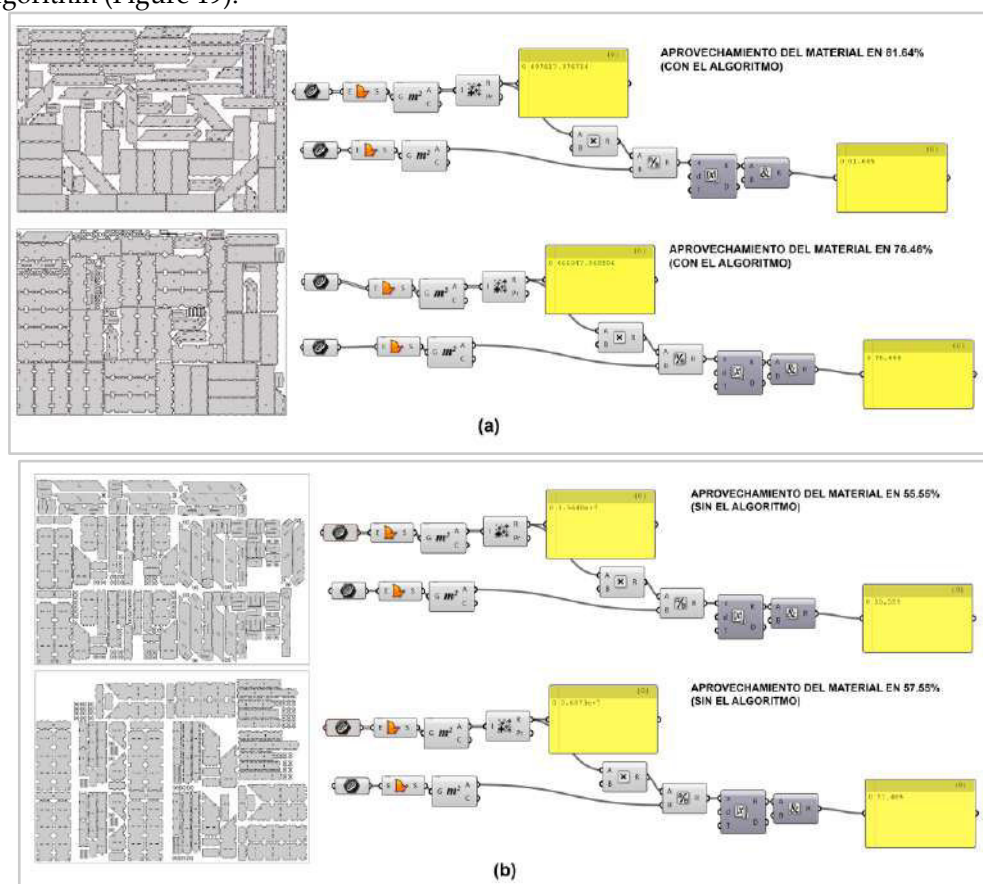




**Figure 18.** Phase 7 of the development of the algorithm for optimizing modular pieces in laser cutting material.

### 3.4. Use of the Material

To verify the efficiency of the algorithm, another algorithm is developed that allows us to calculate the material usage efficiency based on the pieces arranged by the previous algorithm (Figure 19).



**Figure 19.** Chart of the material usage optimization algorithm.

Figure 19 shows the comparison of two models of arrangement for the modular pieces. In the Figure 19a, the pieces were arranged using the algorithm with a processing time of 5 min. In the Figure 19b, the pieces were arranged manually, taking 30 to 45 min to place them in the most suitable way on the material, with the possibility of making errors in the quantity of pieces required per module due to the manual process.

The final result of the algorithm in terms of material utilization demonstrated a 20% higher efficiency compared to performing the same process manually. Additionally, the use of the algorithm significantly reduces the time needed to organize and code the pieces.

### 3.5. Model

With the development of the physical 1/10 scale module (Figure 19), the effectiveness of the algorithm for all modular pieces required for the module was verified. Additionally, economic savings were also confirmed.

Figure 20 represents the final model of the prototype. Regarding the final model costs, for its assembly, 25 sheets of material were used (Figure 18) with a total cost of S/.325.00, where, in most cases, the pieces were manually placed without the use of an algorithm. Subsequently, all the pieces were loaded onto the material using the algorithm, resulting in a material utilization of 18 sheets with a total cost of S/.234.00, representing a cost savings of 28% compared to manually ordering and coding everything.



**Figure 20.** Physical model in 1/10 scale of the modular house.

## 4. Discussion

In the realm of multi-local social housing construction, prefabricated steel module systems, known as PPVC (Prefabricated Prefinished Volumetric Construction), have emerged as an alternative, addressing both bioclimatic aspects and structural resistance, especially in high-altitude contexts. However, limitations in these systems have been identified, mainly related to the connection between volumetric modules and the loads generated by their own weight. Although techniques and methods exist for the construction of medium and high-rise buildings [22], the need to improve flexibility and adaptability persists. In this context, this article highlights the use of the WikiHouse system as an innovative digital tool that overcomes the aforementioned limitations.

The WikiHouse system features impeccable modular design, allowing the relocation of doors and windows, as well as the efficient alteration of the design and model, adapting to the specific conditions of each location. The results obtained during the assembly process demonstrate the inherent efficiency of the WikiHouse system [46]. The ability to maintain structural unity while exhibiting flexibility for various design needs highlights the versatility and adaptability that this digital tool brings to the field of multi-local social housing construction.

The WikiHouse system aligns comprehensively with long-term social, economic, and environmental sustainability [47], specifically with circularity principles in the realm of housing construction [48]. Through its innovative design and construction approach, WikiHouse incorporates key aspects of the circular economy by prioritizing resource efficiency, reuse, and adaptability. The inclusion of new pieces in the housing model not only meets rigorous structural standards but also strategically aligns with circular economy principles. In this regard, the use of wood in WikiHouse stands out as a renewable resource with lower environmental impact, which, when employed, would reduce carbon emissions. Therefore, it is essential to consider greenhouse gas emissions in the construction sector from the perspective of life cycle analysis, which would help overcome barriers to implementing the circular economy in construction [49].

The use of wood in WikiHouse not only promotes sustainability, due to its lower CO<sub>2</sub> emission rate and reduced environmental impact compared to steel or aluminum [50], but also contributes to mitigating climate change. Wood products serve as a carbon storage depot and can replace environmentally harmful sources of materials and energy, such as fossil fuels. These incentives to increase the use of wood products (Harvested Wood Products, HWP) are implicit in the Kyoto Protocol, as substituting fossil fuels with wood-based fuels and energy-intensive materials with wood-based products is a means to reduce carbon dioxide emissions [51]. Additionally, at the end of their lifespan, wood components in the WikiHouse system can be reused or recycled, reducing waste compared to conventional construction and demolition methods. The modular design of the WikiHouse system also stands out, enabling efficient construction and minimizing material waste. Precision in CNC (Computer Numerical Control) cutting ensures optimal utilization of each piece, essential for sustainable resource management.

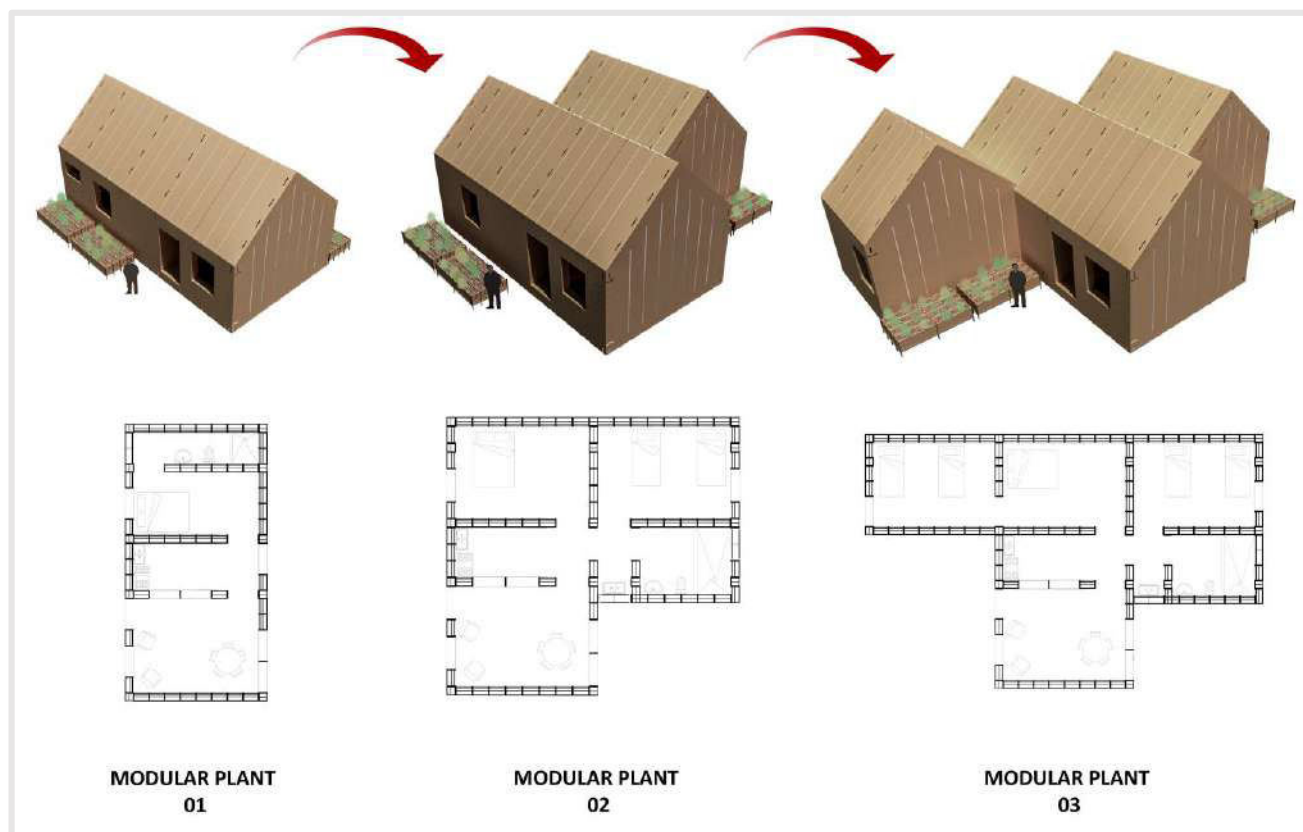
In Figure 21, the different phases of the circular economy model implemented by WikiHouse are presented, prioritizing efficiency in resource use, reuse, and adaptability.



**Figure 21.** Diagram of the circular economy model implemented by WikiHouse.

The application of polyomino theory in architectural development has introduced a modular composition that demands a base measure to facilitate space organization [52]. However, the use of these spatial modules becomes less flexible when faced with the task of generating irregular environments. In contrast, the WikiHouse system offers the flexibility needed for the creation of unrestricted spaces, without being limited to a rigid or strict modular structure, as well as ease of implementation in various locations due to its efficient assembly feature, enabling a diversity of shapes in its composition.

Figure 22 highlights the system's flexibility in adapting and adding new spaces over time, according to the specific needs of the user.



**Figure 22.** Chart of modifications to the base module.

In the realm of steel structural design, its properties, promoting durability, strength, and adaptability to various physical needs stand out. Despite the numerous virtues of steel, manufacturing components for structures in this material involves higher energy consumption. The main contributors to CO<sub>2</sub> emissions in buildings with steel structures are attributed to 52% for the production of steel beams, with the production of these structures being the primary factor in energy consumption. Additionally, since manufacturing is performed in specialized areas, the transportation of elements and tools is part of the total energy consumption [22]. On the other hand, the use of wood in architectural design offers greater adaptability, strength, flexibility, and comfort for users, making it a versatile material for application in different environments, as mentioned in previous paragraphs. Thus, in Table 1, it is shown that a steel housing prototype has significantly higher costs due to the amount of energy and the quantity of materials used in its manufacturing. In contrast, in the case of construction with wood, this stands out as the lower-cost option, besides being in harmony with its surroundings.



**Table 1.** Comparison of steel and wood housing prototypes: Cost and material life cycle.

Housing prototypes	Material Cost	Material Quantity	Material Life Cycle
Steel Housing Prototype Case	850 EUR/m <sup>2</sup>	Indefinite As it is a manufactured material, it has a greater possibility of using	Transport 19%
Wooden Housing Prototype Case	230 USD/m <sup>2</sup>	Enough It is regenerated from the circular economy	Transport 5%

In a community in the Negev Desert in Australia, a methodology was developed to create a temporary mobile infrastructure with the assistance of the community [28]. However, this cannot be adapted to other parts of the territory because it is a closed-source system. In contrast, the open-source nature of WikiHouse contributes significantly to its adaptability and widespread use due to its collaborative development. Being open-source allows a community of developers, architects, and enthusiasts to collaborate on the continuous improvement and refinement of WikiHouse. This collective effort brings diverse perspectives and knowledge, enhancing the system's adaptability to various needs and contexts.

The tentative documentation of an emerging production prototype known as “global design, local manufacturing” or “DGML” [53] has demonstrated the innovative capabilities of commons as an alternative route for technological development in response to social needs [54,55]. Constant research into this alternative social perspective could reveal new opportunities to explore and apply practices that drive more equitable and sustainable innovation, thus improving the ability to more effectively meet social needs and address global challenges, such as the climate crisis.

In the context of homes for low-income individuals, quality of life [33] is significantly affected by bioclimatic concepts, with natural ventilation management being a key component following a low-cost approach [34]. In the proposal presented in this article, cross-ventilation is implemented in main spaces as an integral part of this bioclimatic strategy.

This research has thoroughly explored the impact and implications of implementing the WikiHouse system in the context of multi-local social housing construction. Through the evaluation of its versatility, sustainability, and adaptability, its crucial role in addressing identified limitations in other prefabricated systems has been highlighted. The versatility of WikiHouse has been demonstrated in its ability to efficiently alter the design, adapting to specific conditions of each location. This distinctive feature, supported by the ongoing collaboration of the developer and architect community, as well as the open-source approach, underscores the transformative potential of commons-based practices and collaborative innovation. From a sustainability perspective, WikiHouse stands out by incorporating principles of circular economy, resource efficiency, and material reuse, with a particular focus on wood as a renewable resource with low environmental impact. This application aligns comprehensively with long-term social, economic, and environmental sustainability, marking a significant advancement in the field of sustainable construction.

## 5. Conclusions

When comparing the versatility of AI-based parametric software and human skills, it can be concluded that the use of software such as Grasshopper version 1.0.0007 has significantly improved design efficiency and reduced material usage in the manufacturing of modular parts for the Wikihouse system. The Grasshopper software version 1.0.0007,

combined with the open-source nature of the system, is key to addressing material scarcity, reducing energy consumption in construction, and lowering costs associated with manufacturing and processing. These tools enable faster and more efficient development and, with ongoing digitization, systems like Wikihouse are increasingly important due to their open-source nature, promoting dissemination and enhancing the viability of executing architectural projects in various locations.

In the construction system developed in this research, several advantages and disadvantages can be identified when considering its application in construction in terms of the physical environment, climatic conditions, and user comfort needs. In the case of the Wikihouse system, the use of eco-friendly materials, such as wood, stands out, offering numerous benefits. Wood not only contributes to maintaining and creating a favorable environment for both the surroundings and its users but also possesses physical properties that make it widely accessible and sustainable. Its availability and ease of use make it an efficiently sustainable option.

The execution of architectural projects involves the need to meet requirements that cover the complex and specific needs of each project. However, architecture does not necessarily follow a strictly linear approach. Based on this premise, it can be inferred that the design of an architectural space should adapt to the environment and specific needs.

Regarding the capabilities of the Wikihouse system, its virtuous ability to be implemented in various locations stands out due to its efficient assembly feature, without being limited to a rigid or strict modular structure. Therefore, this system provides flexibility in design, which is a distinctive feature of architectural works.

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